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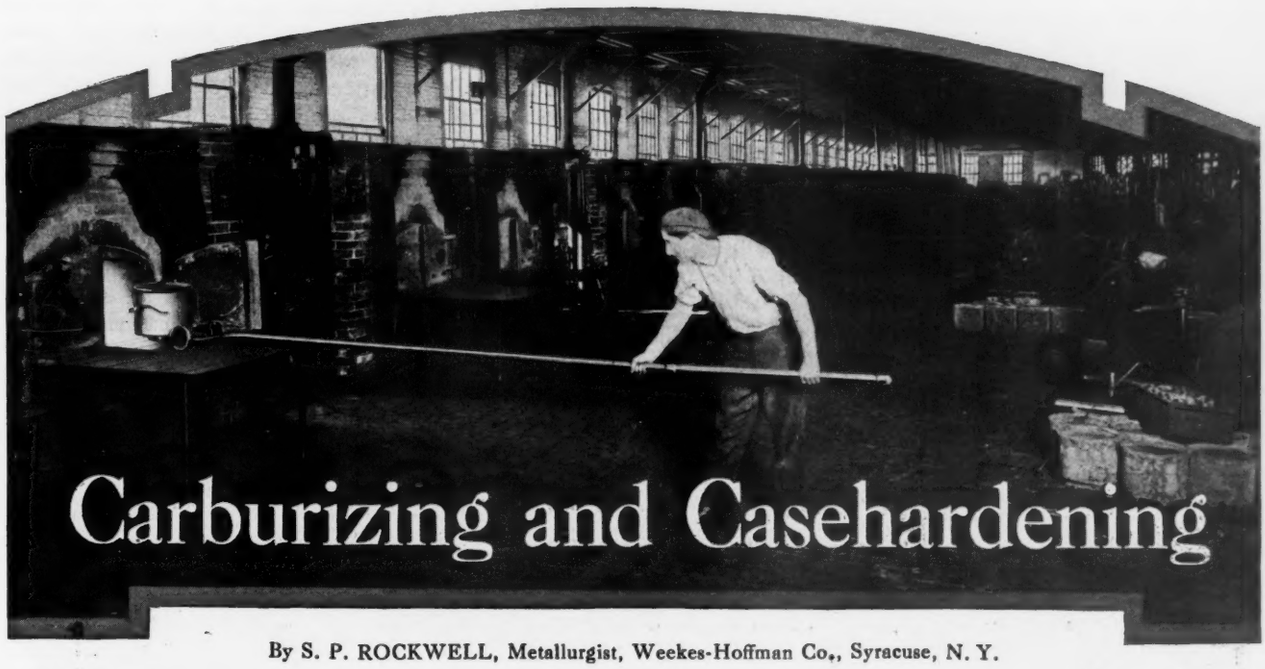

Carburizing and Casehardening

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First of a series of articles on the latest practice in carburizing and casehardening, covering different classes of carburizers, their selection and characteristics; steels suitable for carburizing; carburizing pots and methods of packing and sealing them; temperatures required for carburizing; treatment after carburizing; cyanide hardening; various kinds of quenching mediums, furnaces and fuels; valuable cost data; and many other subjects of importance.

CARBURIZING and casehardening have developed rapidly during the last ten years, due primarily, to the rapid advance of the automobile industry. In view of these developments, a complete record of the present state of the art has been deemed necessary, and it is the author's object, in the following articles, to deal with the various materials, equipment, and methods used in carburizing and casehardening. It has been the author's aim to write these articles so that they will be understood by men who are not versed in the theory of metallography, but who are engaged entirely in the practical work of heat-treatment. Hence, everyday terms have been used as far as possible and technical phrases, in general, have been avoided.

Briefly defined, casehardening is the process of increasing the carbon content of the surface of steel. The steels so treated are generally low in carbon, and the object is to raise the carbon content of the surface until it may be hardened by the usual method of heating to a hardening temperature and quenching in a cooling bath. Hence, the term "casehardening" implies the hardening of the surfaces or skin of a part made from steel. The process of increasing the carbon content of the surface is known as "carburizing" and the actual hardening process is known as "casehardening." The carbon content is increased by heating the steel in the presence of materials high in carbon, so that the latter element which has a great affinity for iron, has an opportunity to combine with it in the surface of the steel. The materials used for carburizing steel are known as "carburizers."

Carburizing material in general is a carbonaceous material, which gives off as its chief ingredient carbon monoxide gas. Other gases given off are really impurities. Charcoal, coke, or anything which burns to charcoal or coke when burned with a minimum amount of air is really a carburizer. Alone, however, these materials are not suited for all cases of carburizing inasmuch as the carbon monoxide gas is not controllable in its volume given off and its intensity. Usually chemicals or a catalytic agent is added to the carburizer, or the coke or charcoal product, which is known as the generator, and this chemical or catalytic agent has been termed an energizer. The energizer, therefore, is some product which regulates the volume and intensity of the gas given off by the generator, but which in itself does not take a definite part in the actual carburizing operation.

Types of Carburizers

There are, strictly speaking, but four standard types of carburizers; they are classed by their physical form as follows: (1) Powder materials, in which the generator and the energizer are in a powder form and are thus mixed together. (2) Pill materials, in which the generator and the energizer are in a powder form, but are held together by a binder which in itself may be either a generator or an energizer. (3) Pellet materials, in which the generator is a granule of solid carbonaceous material coated with an energizer by the help of a binder. (4) Pellet and powder materials, in which the generator is a granule of solid carbonaceous material, and the energizer is in the form of a powder. A certain per cent of the powder may also be a generator. Different combinations of the above four forms may be found, but no great value should be attached to claims for their importance.

Two other mediums are still used to some extent for carburizing, namely, bone and leather. Bone is classed as a pellet material, with the exception that the energizer is contained in the bone in the form of ammonium carbonate. The ammonia fumes are quite noticeable when water is poured on red hot bone. Leather is classed as a powder material due to its being so easily powdered. The energizer is in the form of cyanogen and is contained within the leather.

Charcoal, coke and coal should not be classed as carburizers, as they are nothing more than generators. Alone, they are not easily controlled as regards penetration and percentages of carbon entering the steel to form the case. There are a great number of commercial carburizers on the market in which the materials used as the generator may be hard and soft wood charcoal, animal charcoal, coke, coal, beans and nuts, bone and leather, or various combinations of these. The energizers may be barium, cyanogen, and ammonium compounds, various salts, soda ash, or lime and oil hydrocarbons. There are no secrets concerning these compounds. In the selection of a carburizer, the main points to be taken into consideration are whether the material of-

fered is best fitted for the work in hand, whether it contains impurities making it useless for the work, and whether the company manufacturing it has had sufficient experience so that a uniform product can be had at all times.

Experiences of Firms Manufacturing Carburizers for their Own Use

The compounds sold on the market could be manufactured by the user, but he should take into account the following points: (1) Are his purchasing requirements as great for the ingredients making up the carburizer as the manufacturer's who specializes in making carburizers? (2) Will he save enough to pay for the cost of labor, mixing machinery, and tanks? (3) Can he be assured that all his raw materials will be uniform? (4) Can he rely on obtaining a constant mixture and strength of finished material at all times?

The following experiences show the errors into which concerns making their own carburizer sometimes allow themselves to be led. A certain concern which manufactured spring shackle bolts used leather for a carburizer. It bought raw leather for $12 per ton. This leather had to be charred in order to use for carburizing, and to do this 112 pounds, worth 67 cents, was packed in pots. A furnace was then given up for the charring. The cost of charring including fuel, power, depreciation, labor, and pot loss was $2, taking no account of the possible holding up of further production. The total cost for the operation was then $2.67. While charring, the shrinkage in volume and weight was so great that only forty pounds of leather was left. The cost per ton of carburizer ready to use was then $133.50, or about $2.50 per cubic foot. This material could be used twice, so that the cost per useful ton was therefore $66.75 and the cost per useful cubic foot, $1.25. The cost per useful ton of the commercial carburizer later used in place of this, was only $11, while the cost per useful cubic foot was only 14 cents.

In another instance, a concern bought soft charcoal for $25 per ton. This was powdered at a power and labor cost of $3.50 per ton. To a ton of this charcoal were added twenty pounds of fine salt worth $1. The whole was then dampened with seven gallons of coal oil costing 70 cents, which brought the cost to more than $30 per ton. As this material caused soft spots on the work after the first heat, it was not used more than once. The cost per useful ton was then $30 and the cost per useful cubic foot was 75 cents. The cost of a commercial carburizer for this class of work was only $10 per useful ton or 20 cents per useful cubic foot.

In a third case, bone was used for carburizing. The cost of good quality shin bone was $60 per ton uncharred or about $1.33 per cubic foot. This material was used three times before discarding, by mixing one-third unused with two-thirds used, after each heat; so the cost per useful ton was $20 and the cost per useful cubic foot 44 cents. The market price of a good commercial carburizer was $11.25 per useful ton, or 15 cents per useful cubic foot.

Selection of a Carburizer

The selection of a carburizer should be governed by the desired quality of the finished product. When manufacturing high-class products, impurities in the carburizer that might affect the proper results should be carefully considered. Sulphur and phosphorus are the two impurities that cause the greatest trouble in carburizing and are therefore the greatest drawbacks. Hydrogen sulphide in some of its forms is sometimes used as an energizer, and water sprinkled on such an energized material will cause fumes to be given off. Materials having coke and coal as the base or energizer are rich in both sulphur and phosphorus. Bone and leather also contain them, the residue of bone being calcium phosphate, while leather is often tanned with chemicals containing these elements. Just what proportions of these elements are necessary in order to be harmful to the steel is a question. It stands to reason, however, that it is unwise to subject the steel to these impurities when the steel maker is trying to hold the sulphur and phosphorus contents as low as possible. Supposedly, sulphur enters the case and combines with the manganese to form manganese sulphide. Extreme brittleness is often due to sulphur infusion.

Chemicals are sometimes used in a carburizer in order to hasten the penetration. They may or may not be impurities as regards the internal effect on the steel. When manufacturing parts which merely require a surface hardness and on which strength and wearing qualities are minor considerations, it is not necessary to pay an excessive price for the carburizer. Such work will probably not be endangered by impurities, and a carburizer consisting of nearly any generator and energizer can be used, provided it is economical from other standpoints. Such cases, however, are few, as

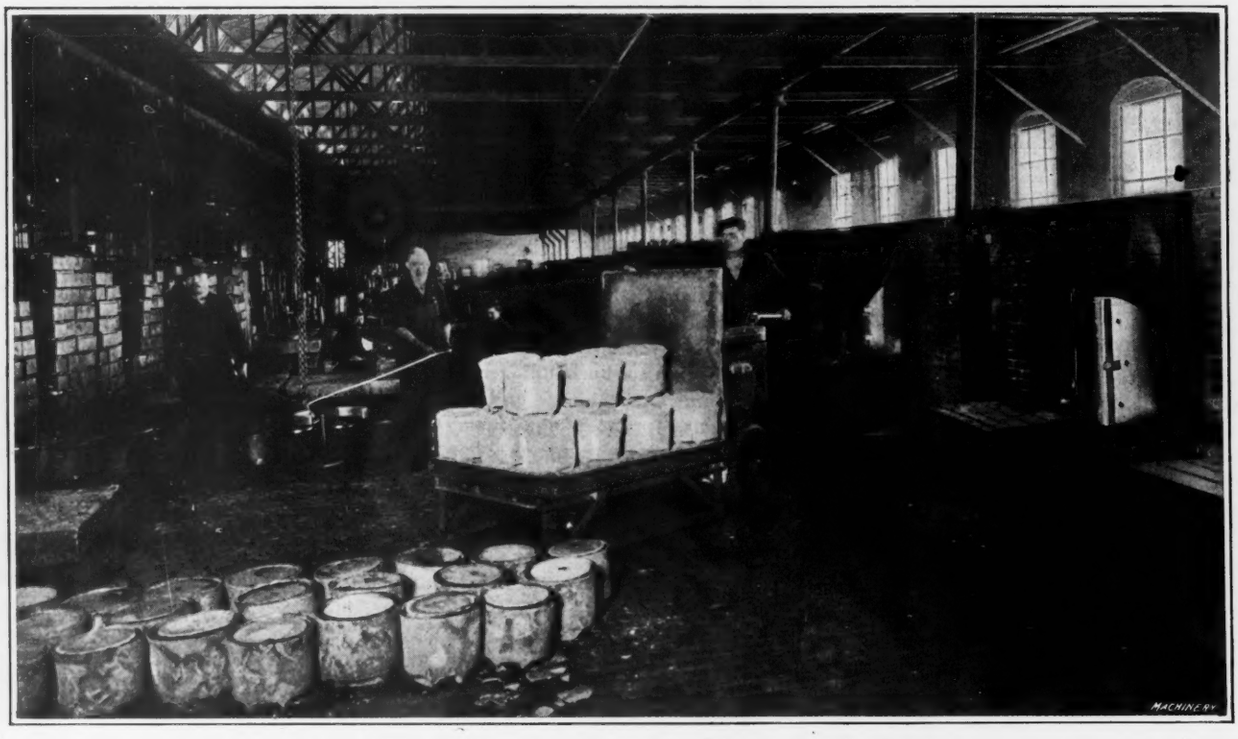

Fig. 1. Carburizing Department of a Large Ball Bearing Manufacturing Plant

nearly all carburized work must withstand wear or shock. A concern engaged in manufacturing set-screws of large size formerly used a carburizer which had been recommended by a manufacturer of ball bearing parts. This material gave excellent results, but at a fairly high cost. The set-screws required a hard surface for a depth of only a few thousandths of an inch and the depth of this case was so small in proportion to the size of the screw that it did not affect the strength of the screw. Results meeting all the specifications were later obtained with a material of a cheaper quality at about half the former cost.

Rate and Depth of Carbon Penetration

For parts requiring an excessive depth of case, a carburizing material should be used that has the necessary lasting qualities and endurance. Ball bearing parts of the larger sizes are carburized to a depth of ½ inch. Plug gages are also deeply carburized so that they may be ground to a smaller size after being worn. A long time is required to carburize such parts, and the carburizer must be capable of evolving sufficient gas during the operation to take care of the steel at all times. Bone, if used for such work, would soon lose its carburizing qualities and would start to decarburize the pieces. Oil hydrocarbon energized materials of a fine mesh seem to answer this purpose better than barium energized compounds of a coarse mesh. It also appears from experiments on work which was deeply carburized that the gas evolved must decrease slowly as the penetration increases, because the greater the depth of carbon penetration, the slower the action.

The chart in Fig. 3 shows the penetration and time curves of a barium energized carburizer while Fig. 4 shows those of an oil hydrocarbon energized carburizer. It will be noted that the set of curves in Fig. 3 shows faster penetration than the set of curves in Fig. 4, whereas the latter do not fall off in their rate of penetration as rapidly as the former. The curves represent the rate of penetration on samples taken from the same pot at the same time. Curve 1 represents a cold-rolled rod where the depth examination was made by means of a rough fracture, while Curve 2 represents a similar rod on which the examination was made by polishing and etching with nitric acid. Curve 3 represents the concave surface of a ball-bearing raceway, and the apparent depth of penetration is less than on the first two curves. This misleading phenomenon will be taken up in a later article. The parts treated by the barium energized carburizer were subjected to 14½ working or carburizing hours and were in the furnace a total of 19 hours, while the parts treated by the oil hydrocarbon energized carburizer were subjected to 11 carburizing hours and were in the furnace for 13¾ hours. The temperature of the furnaces in both instances was 1700 degrees F.

The process of carbon absorption is retarded both by the high percentage of carbon and the increase in the thickness of the layer. If allowance is not made for this, the carbon will pile up on the surface, showing freckled edges, free cementite, and pigging or carbon thrown out of solution, as may be seen in the magnified view shown in Fig. 6.

Mesh of Carburizer Dependent on Work

The mesh of the carburizer should be governed largely by the size of the individual work. In no case should the granules of the carburizer be larger than the greatest dimension of the individual pieces. Powder carburizer is often used for work of large size on the assumption that the carburizing process is a contact process and not a gas process. It is, however, a good point to have small holes filled up with the carburizer as this will prevent dead air or gas pockets and will cause a better circulation of the gas over the whole of the exposed surfaces. A powder carburizer is more dense and as a rule will shrink less than a pellet or pill form of carburizer. On the other hand, such a carburizer, being denser, will have less volume per ton and consequently will cost more per cubic foot. Powder carburizers will not heat through to the center of the pot as readily as an open form of carburizer and the carburizing of the steel will not start as soon—pot, work, and furnace conditions being equal. The explanation of this is that with the open form, the heat conducted through the outside of the pot first heats up the carburizer in contact, which emits gases. These gases then move by thermo-syphon action, carrying their own heat both upward and toward the center of the pot, heating the whole more uniformly than with the powder carburizer, whose gases are restricted to more of an upward movement.

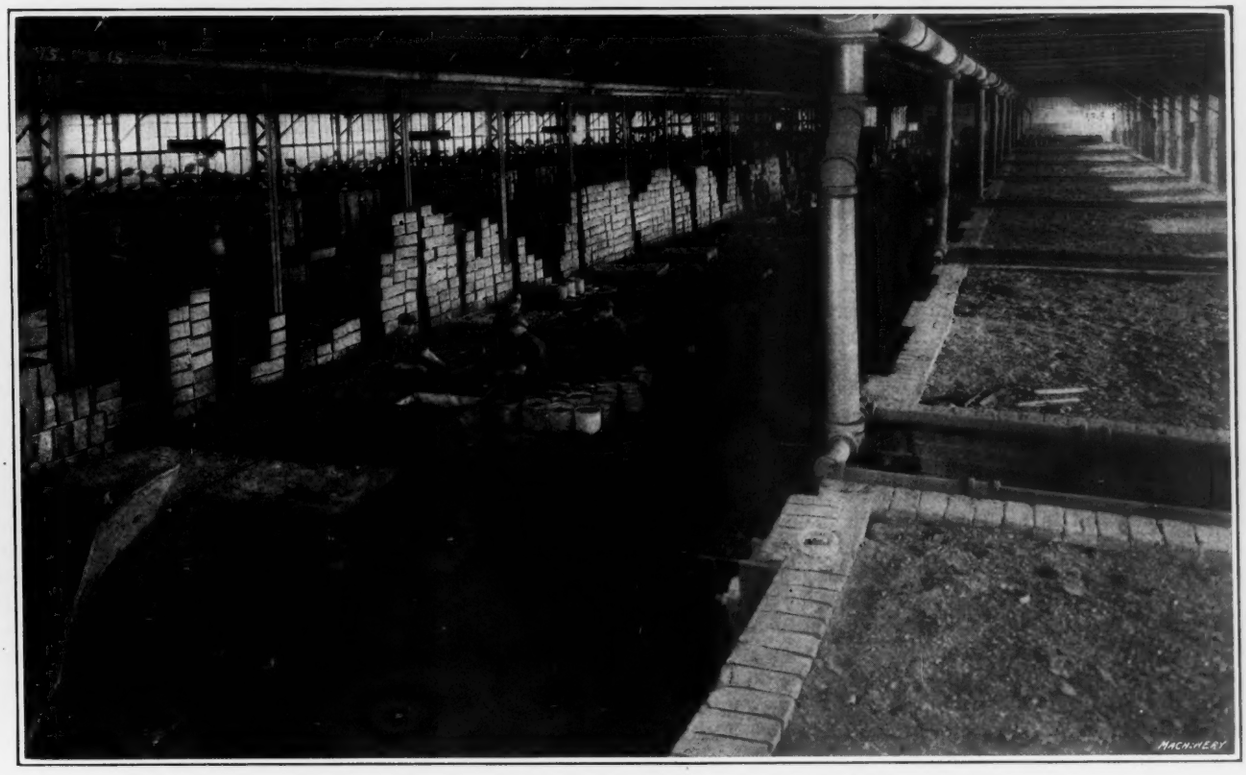

Fig. 2. Another View of Large Carburizing Department in Ball Bearing Plant

Instances where Carburizers Containing Excessive Chemicals Should be Avoided

When work is protected by copper plating for local carburizing, a material with excessive chemicals should be avoided. Even with the best of copper plating, it is found that few chemical carburizers can be used. Barium, ammonium and similarly energized carburizers will apparently break down the copper and allow the carbon to penetrate. Bone is the only exception to this rule that is known. Bone black and charcoal base carburizers with oil hydrocarbon energizers are apparently the most satisfactory materials to use for copper-plated work.

In an experiment in making a carburizer for copper-plated work on ball bearing races, a base of charcoal and sugar bone was used. The specifications on the work called for a depth of from 3/64 to ⅛ inch, and in each case an analysis of 0.005 inch thickness of the surface was required to show a carbon content of 0.9 to 1 per cent. Alone this material could not be depended on to give a carbon percentage of over 0.8, and it was therefore necessary to use an energizer. For this purpose a water solution of sal-ammoniac was added and it was found that when enough had been added to start to increase the carbon percentage and likewise the rate of penetration, the copper broke down completely.

Excessive chemicals should also be avoided where the finished article is not ground but is buffed and must have a highly finished surface free from pit marks, because certain energizers leave the surface of the steel in a pitted condition. This may take place during the carburizing operation or may be a chemical or rusting action even before the heat is applied and while the work is in contact with the carburizer. Sometimes the action may cause a scale to be formed on the work during heating, and on cooling or during some range of temperature this scale is reduced. The result is a skin that adheres irregularly to the surface of the work.

A concern which carburizes gears changed its customary carburizer for one in which the energizer was a strong combination of ammonia and cyanogen compounds. The gears, after hardening, were covered with a thin pliable dull silver skin. In buffing and scratch brushing, most of this film was removed and in such areas a bright surface resulted, but small particles of this film defied the scratch brush and adhered to the steel. These particles caused a slight elevation on the surface of the teeth and a discoloration. It was claimed that these elevations caused noise in the gear action. If it had been possible to grind the gears they would have been all right from other standpoints. A similar condition was experienced by a firm that manufactured skates. The carburizer which was a charcoal base material having a sodium carbonate energizer left a black soot on the finished product which was harmful only in that it filled up the buffing wheels and slowed up production. Alkali washes or pickling would not remove this condition. The carburizer used in the preceding case was then tried with the same

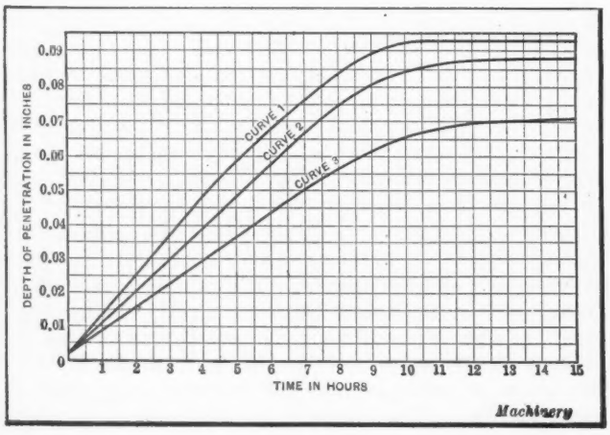

Fig. 3. Chart showing Penetration and Time Curves of a Barium Energized Carburizer

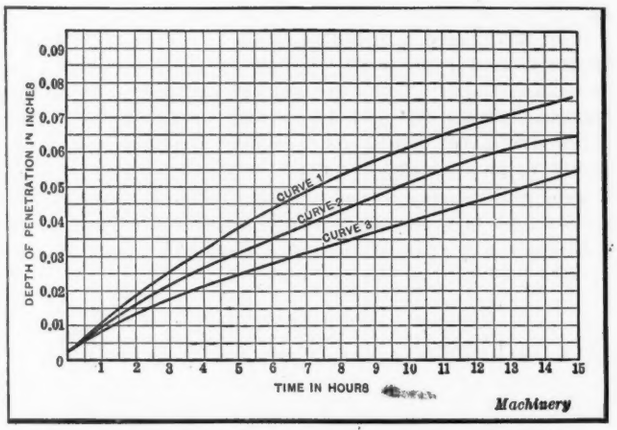

Fig. 4. Chart showing Penetration and Time Curves of an Oil Hydrocarbon Energized Carburizer

results as found in that experience. A charcoal generator material with a barium carbonate energizer was next tried with excellent results, this carburizer leaving the surface in a clean condition, free from soot, pits, or films.

Life of a Carburizer

The life of a carburizer is an important consideration if both slight and great depth work is to be handled. In such an instance it might be economical to have two forms of carburizers. The great depth carburizers are usually a little slower in penetration than the slight depth materials. A certain manufacturing concern used a charcoal generator material with barium carbonate as an energizer for work requiring heats of from 4 to 15 hours, the average heat being about 10 hours. They added, after each heat and after screening, an average of ⅛ new material to ⅞ of the used, which gave one volume of the material a life of about 80 hours. In carburizing some ball bearing parts to great depth it was found that after using this material from 25 to 30 hours, it ceased to penetrate any further and started to decarburize the work. It is interesting to note that such an energizer in a carburizer will lose its power on heat application, but if not carried too far will absorb carbon monoxide from the air when exposed to it and will be thus recharged to a considerable extent. The difficulty in carburizing these parts was eliminated by using a material of medium mesh consisting of a charcoal generator and either an oil hydrocarbon or cyanogen compound energizer. It was also found that if the cyanogen energized material was given a short initial heat at a temperature of approximately 1600 degrees F. before use, the initial shrinkage was removed and satisfactory heats of over 100 hours were obtainable.

Shrinkage of a Carburizer

Shrinkage of a carburizer is desirable to some extent, but too much is liable to expose the work in the pots to the scaling effect of air and furnace gases. On the other hand, too little usually denotes that either an excessive filler is used or that the proper evolution or release of gases is not taking place. Results cannot be obtained except at the expense of solid matter being gasified. A perfect carburizer is one that will be completely gasified, leaving no residue, and at the same time give off gas of a constant composition and in only sufficient volume for the steel to absorb. It is, of course, impossible to obtain such a carburizer. Bone is one of the carburizing mediums that does not shrink to any great extent but leaves a large and wasteful residue and is of little value for great depth work. Shrinkage of a carburizer is largely governed by the method of sealing the pots and the style of pot used. Many users of bone do not seal the pots and for this reason, when commercial types of carburizers have been tried in competition, the pots have not been sealed, with the result that the carburizers have greatly shrunk and on this account are disqualified. It is because of the poor sealing of pots that commercial carbur-

izers are mixed with a certain percentage of inert filler. If the sealing of pots was uniform and of such a quality that only enough gas was released to keep the pot from blowing up or blowing out its seal, then a carburizer containing about 95 per cent gasifiable matter could be used and with the greatest economy. This is more nearly possible with the use of inverted pots and with the nichrome pots that will be described later.

A concern which used a bone carburizer tried out a number of commercial carburizers without success. Upon investigation it was found that they were only covering the pots with a loose piece of sheet iron, and that there was a space of from one to two inches around this iron where the furnace gases could consume the material. The hardener was adverse to changing his methods of sealing and so a special carburizer was made up containing about 65 per cent inert material. With such an amount, the shrinkage was no more than the bone shrinkage had been. Less weight per cubic foot, and equally good penetration and length of life gave the hardener confidence in this material and, on further promises of economy, he agreed to seal his pots by luting the cover with clay. As soon as this was done a standard carburizer containing but little inert filler was submitted and excellent results were obtained. It was interesting to note in experiments made at the time, that the life of the bone was increased 30 per cent by sealing.

Effects of Fast Penetration

It is to be regretted that the sales argument of fast penetration has been used so much. Rate of penetration is governed by the proportions of the gases given off and the degree of heat. Claims for a wonderful degree of penetration should not be given great consideration as tests of 75 per cent of the commercial carburizers showed that the rate of penetration for the first 1/32 inch was equal. From this point on, some showed more rapidity. The advantages of too rapid penetration are often annulled by excess chemicals, lack of endurance from quick spending of themselves and lack of proper gaging of depths on small parts. A fast penetration is sometimes caused by internal combustion within the pot and in such a case the temperature of the work may be slightly higher than the furnace temperature with the obvious disadvantages.

A coke generator with a complex energizer has been largely advertised as a very rapid penetrator. At least three concerns, in the knowledge of the writer, have had the experience of having the work melt in the pot while the outside of the pot showed no signs of overheating. At one of these concerns the writer saw the entire heat and can vouch that the furnace temperature did not at any time exceed 1750 degrees and that the burner flame did not touch the pots.

Purchasing and Comparing Carburizers

As carburizers are bought by the ton but are used by the cubic foot, the makers of these materials try to supply a material light in weight which will at the same time fulfill the requirements pertaining to life, such as shrinkage, etc. Bone at $60 a ton is more expensive than another carburizer at $100 per ton, if the latter contains 75 cubic feet and all other conditions are equal. Carburizers vary in volume from 40 to 100 cubic feet per ton and the cost per cubic foot should be a guide in the selection of a carburizer not forgetting, however, to take into consideration the other points brought up in this article.

The question often arises as to the proper method of comparing a carburizing material with other carburizing materials. Table 1 shows the method used by one of the concerns previously mentioned, in comparing three different carburizers. The various materials are represented by *A*, *B* and *C*, *A* and *B* representing the materials compared with *C*, which was unsatisfactory.

The materials are first compared with respect to their cost and volume, then to their shrinkage and life, and finally, to their actual cost, which is based on the number of times that the material can be used. The first and second heats each lasted five hours, the temperature being 1650 and 1600 degrees F., respectively. It will be noted that the shrinkage of material *A* for the first heat was 37.5 per cent; for the second heat, 10.4 per cent; and for the third heat, 7.5 per cent. These percentages are based on the shrinkage of the total contents in the pot both before and after the first heat, which means that the percentage of shrinkage of the new material added in preparing for each successive heat is not equivalent to the shrinkage of the material in the first heat. This is due to the fact that the shrinkage is not uniform throughout the pot, its maximum point being at the top of the pot. The new material is mixed well with the old before each heat, which does not shrink nearly so great after the first heat as it did during that heat.

From tests conducted on twenty-two well-known commercial carburizers it has been ascertained that the shrinkage percentage practically remains constant after the third heat, and it is therefore unnecessary to conduct further tests. On this basis it can be readily calculated that the several materials could be used the following number of times, *A*, 9; *B*, 7; and *C*, 6. With slight variations this method of comparing can be applied to all carburizers of a pellet or granular nature.

TABLE 1. COMPARISON OF COSTS AND LASTING QUALITIES OF SEVERAL CARBURIZERS

Various Comparisons	Carburizers		
	A	B	C
Cost per ton in dollars	90	90	90
Cost per pound in cents	4.5	3	3
Weight of 231 cubic inches in pounds	5	4.25	4.375
Number of unit volumes in 231 cubic inches	8	8	8
Cubic feet per ton	53.2	62.8	61.1
Cost per cubic foot in dollars	1.69	0.955	0.982
Number of unit volumes per pot	24	24	24
Number of unit volumes in pot after first heat	15	14	14
Number of unit volumes lost in first heat	9	10	10
Percentage of loss in first heat	37.5	41.7	41.7
Number of unit volumes added to pot for second heat	9	10	10
Number of unit volumes in pot after second heat	21.5	21	20
Number of unit volumes lost in second heat	2.5	3	4
Percentage of loss in second heat	10.4	12.5	16.6
Percentage of loss in third heat	7.5	9	10.7
Life of material; number of heats	9	7	6
Cost per useful ton in dollars, based on number of times material can be used	10	8.55	10
Cubic feet of material per pot	0.4	0.4	0.4
Cost per pot for all heats, in cents	67.6	38.2	39.28
Cost per pot for each heat, in cents	7.51	5.45	6.55
Cost of loss in material per pot, first heat, in cents	25.35	15.93	16.38
Cost of loss of material per pot, second heat, in cents	7.03	4.78	6.52
Cost of loss in material per pot, third heat, in cents	5.07	3.44	4.20

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The physical properties of the work after the first and second heats are given in Tables 2 and 3, respectively. By referring to Table 2, it will be noted that in the first heat, *A* gave fair results; *B*, very good; and *C*, poor. The results obtained by using the various materials in the second heat were on a par, except that a few pieces of work treated with *C* had soot on the surface which would not come off in the soda bath. The work could be buffed all right, but no doubt this practice would have been detrimental to the buffing wheel if continued. It is obvious that *B* was superior to *C* and *A* for work where a clean surface was desired; where the depth of penetration was slight, especially on the first heat; and where the cost was considered. In subsequent heats *A* gave the toughest core and became slightly more economical, while the cleanness of the parts became more equal. Carburizer *B* also became more economical than *C*.

Selecting Steel for Carburizing

In selecting the steel to be carburized, a knowledge of the requirements of the finished product is of first importance, as the carburizing process will not improve the quality of

the steel. The length of time that the steel is of necessity exposed to high heat will distort the grain. The great value of the carburizing process is the fact that a low-carbon steel, which would not harden under ordinary heat-treatment and which on the other hand can be readily machined, is, by carburizing, given sufficient surface hardness and approximate strength to meet the conditions met by a similar steel of higher carbon content. Again, the value of carburizing lies in the ability of hardening certain parts of the work, which is known as local hardening. Furthermore low-carbon steels are more readily forged than a higher carbon steel and are safer from a standpoint of final strength. The quality of the finished carburized and heat-treated work in comparison with a similar steel of original carbon content depends upon the skill of the hardener and the method of heat-treatment after the carburizing process.

Steels are principally divided into two classes, straight carbon steels and alloy steels, of which the straight carbon steels are by far the simplest to handle. Alloy steels, on the other hand, are being carburized more and more, due to the desire to get greater strength out of a lesser cross-section. Alloy steels are better for certain classes of work which are not carburized than straight carbon steels, and alloy steels, when carburized, compare similarly with straight carbon carburized steels.

Effects of the Various Elements in Steel

The common elements found in steel are carbon, manganese, silicon, sulphur and phosphorus. Steels containing only these elements in addition to pure iron, are known as straight carbon steels. The addition of one or more element such as nickel, chromium, vanadium, molybdenum, tungsten, etc., designates the steel as an alloy steel.

Carbon is the principal element in all steels which gives it the power of attaining hardness on heat-treatment. Each 0.1 per cent of carbon will increase the ultimate strength of the product from 6000 to 8000 pounds per square inch and the ductility, 5 or 6 per cent. File hardness does not occur until the carbon percentage is close to from 0.45 to 0.70 and then only when quenched in water, though a 0.40 per cent carbon gives considerable hardness if in very thin sections. Under general carburizing conditions, the case is from 0.9 to 1.1 per cent carbon and such an amount gives the necessary exterior hardness. Brittleness, however, accompanies this and it is therefore necessary to depend on the core of the work for the toughness. This toughness is maintained only by obtaining a steel having only a sufficient percentage of carbon that it will not harden in the sense of file hardness. It must have sufficient carbon, however, to stiffen

TABLE 2. COMPARISON OF PHYSICAL PROPERTIES OF THE WORK AFTER THE FIRST HEAT

Various Physical Properties of Work	Carburizers		
	A	B	C
Relative depth of case	3	1	2
Appearance when pot was quenched	Clean	Very clean	Dirty
Appearance when pot was cooled	Dull white	Motfled gray	Sooty
Relative appearance when buffed	2	1	3
Relative toughness	1	1	2
Relative hardness	1	2	1

Machinery

under heat-treatment, so that pressure on the case will not cause the case to fall in. Too high a carbon content will cause more difficulty in machining and forging the steel, but, on the other hand, if the carbon content is too low the steel will be too soft to machine without tearing. Too high a carbon steel will not progress so fast in the carburizing operation, though no difference can be detected commercially for less than 1/32 inch in depth. High carbon acts as a check valve; this is upheld by the experience of getting greater depth in one sixteen-hour heat than in two eight-hour heats. Thirty per cent should, in the majority of cases, be the limit of carbon in steel to be casehardened. Higher carbon steels are often treated like a carburized product, but this should be classed under pack-hardening.

Manganese, when in excessive quantities, gives very erratic results, but this condition need not be discussed, as the ordinary commercial steels do not contain excessive amounts. In a way, manganese is like carbon, as from 0.06 to 0.07 per cent of manganese is equivalent to 0.01 per cent of carbon in hardening. It has the valuable property of decreasing the liability of the steel warping in heat-treatment and also allows it to be heated to a slightly higher degree in relation to the increasing amount of manganese. From 0.3 to 0.8 per cent of manganese is generally adopted in carburizing steels. In carburizing, manganese slightly decreases the depths of penetration per unit of time.

TABLE 3. COMPARISON OF PHYSICAL PROPERTIES OF THE WORK AFTER THE SECOND HEAT

Various Physical Properties of Work	Carburizers		
	A	B	C
Relative depth of case	1	1	1
Appearance when pot was quenched	Very clean	Very clean	Clean (Some soot)
Relative appearance when buffed	1	1	2
Relative toughness	1	2	2
Relative hardness	1	1	1

Machinery

Silicon is the least important of the elements in connection with carburizing steels. It rarely occurs above 0.2 per cent. Too high a silicon content will increase the time of carburizing.

Sulphur should never be present in great quantities, but a very low content causes poor machining qualities. If the content is held under 0.05 per cent or preferably under 0.035 per cent, no harm is done to the steel for carburizing purposes. An excessive sulphur content causes a condition of brittleness which is often laid to faulty carburizing. Sulphur has an affinity for manganese, and together they form manganese sulphide streaks in steel which cause lack of strength and start cracks. Sulphur does not affect the rate of penetration in carburizing.

Phosphorus reduces the shock-resisting qualities of carburized work, and if in an excessive amount, causes a coarse grain which is difficult to refine by heat-treatment. The phosphorus content should not exceed 0.045 per cent. Phosphorus also does not affect the rate of penetration in carburizing.

Nickel increases the strength, ductility, and toughness of steel and allows it to stand shocks to a better degree. This element causes the grain to become fibrous or woody. The heat-treatment temperatures are lowered with the increase in the percentage of nickel, and are about 15 degrees lower for steel containing 1 per cent nickel than for a straight carbon steel. Low-carbon nickel steel carburized is on a par with straight high-carbon steel. The commercial steels contain from 0.5 to 5 per cent nickel. To get the best results from this steel, careful treatment after carburizing is necessary. It is particularly adapted for axles, shafts, gears, etc.

Chromium increases the elasticity of steel, and also the hardness, resistance to shock, and resistance to rupture by twisting. It makes the steel closer grained and homogeneous. When used in combination with nickel or vanadium, greater shock-resisting qualities are obtained, such as are required in armor plate. The use of chromium alone gives the steel poor machining qualities, but, when used with nickel, vanadium, or molybdenum, the steel becomes more readily machinable. Chrome steels are not so easily forged as steels containing other alloying elements. The rate of penetration in carburizing is increased per unit of time and the allowable heat variation is increased in both carburizing and hardening. Carburized chrome steels are particularly easy to harden and give satisfactory results. Chrome steels used in carburizing usually contain from 0.65 to 0.85 per cent chromium. When combined with nickel, the

chromium content is as follows: When nickel is from 1 to 1.5 per cent, chromium is from 0.45 to 0.75 per cent; when nickel is from 1.5 to 2 per cent, chromium is from 0.90 to 1.25 per cent; when nickel is from 2.75 to 3.25 per cent, chromium is from 0.60 to 0.95 per cent; when nickel is from 3.25 to 3.75 per cent, chromium is from 1.25 to 1.75 per cent. When used in combination with vanadium, the chromium content is usually from 0.8 to 1.1 per cent and the vanadium content from 0.15 to 0.20 per cent. Lower amounts of chromium of from 0.60 to 0.80 per cent are used with smaller amounts of vanadium, but then the vanadium acts more as a cleanser for the steel. Chromium steels are particularly adapted for ball and roller bearings, engine shafts, etc.

Vanadium is seldom used alone in steels. Its greatest value is in being combined with nickel and chromium. When used alone in straight carbon steels or in other alloyed steels it acts as a cleanser, as it has a strong affinity for oxygen, the removal of which causes the structure of the steel to become denser. Vanadium increases the rate of penetration in carburizing, per unit time.

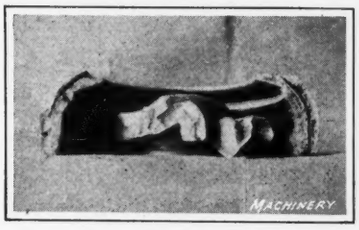


Fig. 5. Enfoliation of a Ball Bearing Part due, primarily, to being cooled too slowly after being carburized

Molybdenum, tungsten, titanium, etc., are lately being introduced in carburizing steels, formerly being used only in high-speed steels; these elements give greater shock-resisting qualities to the steel, tend to retain the shape in quenching, and raise the hardening points.

Material from which Carburizing Pots are Made

Perhaps cast iron is the most common material from which carburizing pots are made, possibly because it is available on short notice and the first cost is low. Malleable iron pots, however, have considerable more life but the first cost is slightly more. Other materials used for pots are, alloy steel, cast steel, puddled iron and wrought iron. The following list shows the results of tests on pots made of these various metals.

Material	Life, Hours	Pot Cost Per Hour, Cents
Malleable iron	465	0.85
Malleable iron	415	0.82
Alloy steel	517	1.68
Cast steel	552	0.77
Cast steel	460	0.87
Puddled iron	475	0.97
Wrought iron	386	2.75
Cast iron	169	1.38
Cast iron	75	4.77

These tests were all made from the same size pot, which was 9 inches in diameter, and 10 inches deep, having walls ¾ inch thick, and will serve as a comparison of the final cost of these pots.

There is a material on the market, known as nichrome, which is high in first cost, being approximately $1.25 per pound; the final cost however, is considerably less than the other materials mentioned in the above. The writer has had personal experience with pots of this material which have shown a life of over 25,000 heat hours and has used the same metal for pyrometer protection tubes in the furnaces where it lasted for five years. The life of this material makes it possible to reduce the wall thickness of the pot, thereby cutting down the weight and cost of the pot and making it easier to handle.

Clay and black-lead crucibles are occasionally used for pack-hardening, but due to the usual rough handling in the hardening shop, they are not practical. Some hardeners prefer to have a firebrick pot permanently installed within their furnaces, which is packed and unpacked in its original position, in which their carburizing is done. They claim that by this method they get a greater uniformity of heat throughout, and likewise, greater uniformity of case. The method is good, but it is a question whether it could be used satisfactorily and economically on a large scale. Ordinary pipe is often used in carburizing and gives a very good life, being also very satisfactory from other standpoints.

Unsatisfactory Results Obtained by Using too Large Pots

The general rule of using a pot only slightly larger than the work is a safe one, but there is no great advantage in commercial work of using pots less than 5½ inches square by 5½ inches deep. Parts such as graphaphone needles are usually carburized in tubes from 2 to 3 inches in diameter and from 8 to 12 inches high, which are placed in a furnace vertically. Watch screws, etc., are carburized in retainers or pots from 2 to 4 inches in diameter and from 2 to 3 inches high.

There are three disadvantages in using a large pot which are as follows:

1. Difficulty in handling.

2. Length of time required to heat the pot and the lack of uniformity of heat from the outside to the center, which means a lack of uniformity of penetration. This is especially important for work requiring a slight depth of case, because if the entire pot is not brought to an even heat, there is danger of carburizing the work near the outside of the pot deeper than at the center. As mentioned previously, a fine mesh carburizer causes more lagging of heat between the inside and outside of the pot than a coarse mesh carburizer. As an example of this disadvantage: In a certain case gun triggers were carburized in pots 12 inches long, 8 inches wide and 6 inches high, and after they were removed from the pots great unevenness of depth was noticed. Marked samples from the outside of the pot were carburized to too great a depth while samples at the center remained uncarburized and would not harden.

3. Likelihood of too slow cooling when the work is pot-cooled. This danger results in a tendency of the carbon in the carburized case to separate into layers on slow cooling, each layer containing a different percentage of carbon. Often an inner layer of medium carbon has approximately from 0.6 to 0.8 per cent carbon, and an outer layer of high carbon has 1 per cent. There is no cohesion between these two layers or zones, and when the work is hardened, a weakness and separation result between these layers which will develop when the work is strained or subjected to wear. The final effect of this condition will be a shelling away of the outer zone as shown in Fig. 5. The name for this is "liquation" or "enfoliation." Pot-cooling will always cause this phenomenon to a greater or lesser degree depending on the rate of cooling, but if the effect is not too pronounced it can be eliminated readily by heat-treatment.

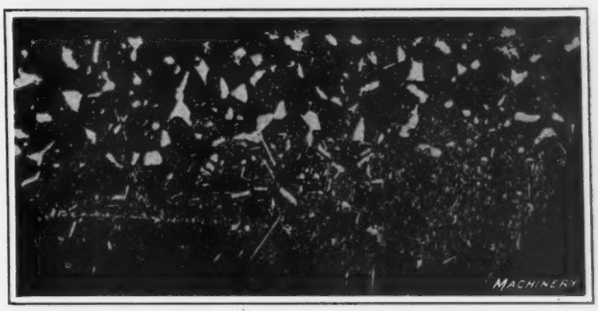


Fig. 6. Magnified View of Work having Carbon piled on Surface due to Retardation of Absorption

The following experience shows that when the pot is too large so that the work cools too slowly, there is not only enfoliation or separation of zones but also a decarburizing effect of the carburizer in close vicinity of the steel, on the steel, because the carbon in the former overbalances the carbon in the steel. A large manufacturing plant making air compressors experienced trouble in carburizing parts made of nickel-chromium steel which were carburized up to a depth of 1/16 inch. On attempting to harden these parts

a softness of skin was found. Fractures of these parts showed that this skin was spread on a hardened surface beneath, and close examination by a microscope showed that there were three distinct layers of metal before the core was reached. The outer layer was practically pure iron; the next layer was extremely high in carbon; and the layer adjacent to the core was of about 0.7 to 0.9 per cent carbon. The trouble was first laid to the carburizing material, and initial tests to determine the truth of this were conducted in small pots with especially prepared test samples, but the conditions of the trouble were not found. About the time that the trouble started, this company had commenced using extremely large pots for the carburizing operation, some of them being 3 or 4 feet in diameter. After thorough investigation it was found that the extreme slow cooling of the work in these pots, after carburizing, caused these separations of the zones and the surface softening. This trouble was eliminated by quenching direct from the pot and then rehardening as if it had been cooled in the pot. In this way the work was produced at a faster rate and at the same time the cooling from the pot gave nearly the same conditions as a reheating for refinement of the core.

Design of Pots

Pots should always be of sufficient size to allow from ½ to 1 inch of carburizer between any part of the work and the pot, slight depths requiring the lesser amount. For large work where the smallest dimension of the piece is greater than 6 inches, it will be found that one piece of work to a pot probably will be better than a number of pieces. This depends, however, on the depth and quality of case desired on the work. It is sometimes advantageous to use a flue through the center of round pots to allow furnace heat to circulate up and through. When the pot is made in this way, large pieces would be packed around this flue.

The height and length of pots is not important except that they must meet furnace conditions and be of such a size that they can be readily handled. The width is the most important dimension since it takes but very little more time to heat a pot 6 inches wide and 2 feet long than it does one 6 inches wide and 1 foot long. The design of the pot is governed to a great extent by the class of work desired. A round pot heats through more evenly than a rectangular pot and is particularly adapted to disks, gears, bearings, etc. A rectangular pot is more economical for other classes of work from a standpoint of inside space. The round pot warps less and does not need warpage cleats, a heavy upper rim being sufficient. When the proper equipment is provided, it will be found that it can be as readily handled as the rectangular pot.

The warpage cleats on rectangular pots depend on the material and the size of the pots. Experience is the best guide for placing warpage cleats. Cast-iron pots warp more than malleable, and both of these more than steel pots; nichrome pots do not warp to any appreciable extent; while rectangular pots usually bulge on the sides, the ends and upper rims falling in. Cast-iron and malleable pots should have a slight taper from the top to the bottom, the bottom being from 1 to 1½ inches less in width or diameter than the top, for every 12 inches in height. This will help to prevent warpage and will allow the contents to be dumped easier, especially when a fine mesh carburizer is used. The wall thickness should be from ⅝ to ¾ inch, the smaller pots requiring the lesser thickness. Greater thicknesses would stand the heat a greater length of time but would most likely have to be discarded on account of warpage before any benefit could be derived from the added thickness.

All pots should have legs or cleats, to hold them off the hearth. The cleats are the more substantial, and their height should be from 1 to 2 inches. By thus allowing a complete circulation of furnace gases around the pot an even heating is insured. For the same reason, pots, especially rectangular ones, should not be allowed to touch one another in the furnace, and there should be at least 2 inches of space between them in all directions.

Fig. 7. Method of packing Nichrome Pots. Note the Beveled Surfaces on the Pots and Covers

Methods of Packing Carburizing Pots

There are in use a number of methods of packing carburizing pots. Some carburizing materials require tamping down, while others require merely a shake or rapping on the outside of the pot. A powder material should be tamped, but a granular material is best settled by shaking or rapping. It has been found that a granular carburizing material, which has been tamped down in the pot, is liable to become crushed into a powder form, and on later sifting, too much is wasted. It is also found that if granular material is tamped down to a certain level and then shaken, it will drop still more.

At least ¾ inch of carburizing material should cover the bottom of the pot and this material should be leveled off fairly smooth. The work may then be placed on this layer, allowing approximately ¼ inch between the surfaces of the various pieces of work, depending upon the required depths of carburization. Corners of the work may be disregarded and brought very close together. It is always best to have at least from ½ to ¾ inch between the work and the wall of the pot. The reason for this is that pots absorb some carbon and are liable to take away some of the strength of the carbonaceous gases, thereby lowering the carbon carrying properties of the gas that comes in contact with the work. After a layer of work has been placed on the layer of carburizer, from ½ to ¾ inch of the carburizing material should be placed over this layer of work and leveled off, after which the former procedure should be continued. After each layer of carburizer has been placed, it is well to tamp the carburizer or rap the pot before adding the next layer of work, so as to insure a perfect settling of the contents. The reason for a greater amount of material between each layer of the work than between each piece of each layer, is because all materials shrink on heat application and as soon as they have reached the heat will begin to settle, so that at the end of the heat, the distance between the work will be found to have closed up to some extent. Due to the shape of the work it is not always possible to pack in layers, but it

is good practice to follow out the above plan as nearly as possible. At least 2 or 3 inches of material should cover the top layer of work when granular material is used and when the material is new. From 1 to 2 inches is sufficient for powder material under the same conditions. After the material has been used and has come to its constant rate of shrinkage, from 1 to 1½ inches is all that should be required with either a granular or powder material.

Various Methods of Sealing the Pots

It is best to seal the pots in order to retain as much of the carburizing gas within the pot as possible. This will increase the pressure which, in turn, increases the rate of carburizing and likewise protects the carburizing material from undue exposure to the air and keeps it from burning and losing its strength. There are various methods of sealing pots. Common fireclay and salt mixed together are used for this purpose. The salt keeps the fireclay from being chipped and glazed by the furnace heat. The mixture is spread over the surface of the pot and trowelled down. Sometimes steel and cast-iron chips are mixed with this clay, which help to form a non-cracking cover. Cast-iron or steel plate covers which fit loosely over the top of the box are also used, the corners being sealed with clay. In some vicinities, ordinary red brick clay is satisfactory for this purpose and is much cheaper than fireclay. In fact, as clays have different fusing temperatures, it is sometimes found that the ordinary clay is more satisfactory than fireclay, due to the fact that heat causes them to fuse and fill up any cracks that may be developed by the pressure of escaping gases. Cast-iron or steel chips alone are a good seal and when placed on the top of a steel or cast-iron cover make an excellent method of covering. The steel or cast-iron chips should not, however, be allowed to get into the carburizer to any great extent.

A concern making chain parts experienced trouble with silica deposits on carburized bushings. The shape of these bushings caused considerable cost in cleaning them and the silica deposits dulled the reamers and other tools. Investigation showed that if the carburizer was not sifted, a magnet placed in the carburizer came out covered with iron filings, chips, etc., and an examination of these chips showed that they were from some other source than pot seals. It was found that clay mixed with sand was used for sealing purposes. This sand was waste foundry sand and contained 2 or 3 per cent of iron. The silicon and the finely divided iron in the sand, and the sodium carbonate in the carburizer, formed silica or glass deposits on the work. By taking clean steel and painting a design on it with the sand and packing with new carburizing material, the design was produced in glass on the steel by the carburizing operation. Elimination of the sand and a thorough sifting of the carburizer relieved this trouble. In conjunction with this, it is interesting to note that alloys in the steel will cause these silicon deposits to take on various colors. With the nichrome pots previously referred to, as they neither warp nor scale, it is found that by grinding the surface of the inside of the pot near the opening to a bevel, and having covers which fit this bevel made of the same material, no luting or other covering is necessary. (See Fig. 7).

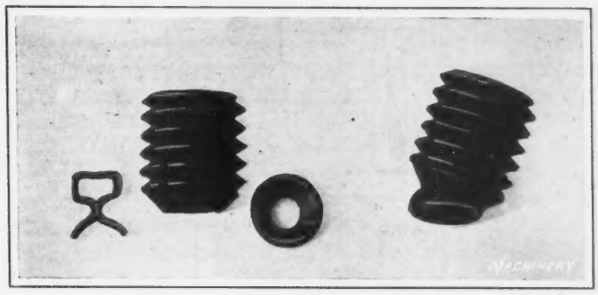
Many concerns do not seal their pots at all and claim that such a procedure is unnecessary for their class of work. Satisfactory work cannot be done, however, without sealing, except perhaps for work having a slight depth of case. For great depth work, uniform results can be obtained only with the best methods of sealing. Non-sealing results in the burning of the carburizing material by air and furnace gases, exposure of the work, scale decarburization, and the escape of the carburizing gas before the steel has received the greater benefit that it would get if these gases were somewhat confined.

In packing, it is well to determine whether it is advantageous to the work from standpoints of desired hardness, grain structure, and strength, to cool the work in the pot or quench from the pot. If it is desired to quench from the pot, in most cases, this can easily be accomplished by wiring or stringing the work to rods before packing. A number of parts can be wired together, and there can be one or several sets to the pot. The ends of the wires should be brought to the under side of the cover where they can be easily grasped by tongs for removal and quenching. In the case of gear pinions, the pinions can be threaded on bolts sufficiently long to reach to the top of the pot. Where the work can be quenched by tipping the pot and contents into a quenching bath or a sieve, stringing is not necessary unless the rough handling mars the work or if warpage is liable when the work is quenched in this manner.

* * *

SELF-ALIGNING AND SELF-LOCKING SET-SCREW

A self-aligning and self-locking safety set-screw is being manufactured by the Bofors Co., Sweden, and is the invention of M. Weibull of that company. This set-screw, which is here illustrated, is an improvement over the well-known safety set-screw having a hollow conical point. The ordinary hollow set-screw loses much of its holding power when it is at an angle with the shaft. Since the efficiency of the screw is due largely to the holding power of the two semicircular incisions which the hollow point makes in the shaft, it is evident that the maximum holding power is obtained when the set-screw is at right angles to the shaft. It is frequently necessary to incline the set-screw, as in the case of a gear having a short hub, in which a hole cannot be drilled at right angles to the shaft.



Ball-point Hollow Set-screw which is both Self-aligning and Self-locking

The improved set-screw which is designed to overcome this condition consists of three parts; a regular hollow set-screw slotted across the point as shown, a semi-spherical loose point, and a holding wire for assembling the two parts together. It will be apparent from the illustration that the wire fits into one of the slots in the set-screw and that the bent ends are the means of supporting the point, and are shaped to conform to the curvature of the inside of the loose point. This loose point has a sharp circular edge like the regular set-screw point, and its spherical surface fits the point of the set-screw and acts like a universal joint. It will be evident that by this means a full bearing of the loose point against the shaft will always be had. Continued pressure on the loose point when tightening the screw will expand the slotted end and lock the screw in the hole. This latter feature makes the set-screw self-locking.

* * *

Among the exhibits of special interest at the Shipping, Engineering, and Machinery Exhibition at Olympia, London, might be mentioned friction linings. There is on display a fabric manufactured by a London firm that is said to meet the serious braking problems of the underground railways of London and Paris and that was used by the British and allied engineers on the clutches and brakes of war tanks. There are in all, thirty-one varieties of friction linings exhibited, each kind intended to perform a special function with loads up to 10,000 pounds per square inch.

Dies for Automobile Muffler Housings

By J. BINGHAM, President, The B. J. Stamping Co., Toledo, Ohio

THE dies used to make the two shells which form the housing for a certain type of automobile muffler are described in the following. The illustrations show the dies and the housing part or shell as it appears after each operation. The corresponding parts of the various dies have the same reference letters throughout the description. The functions of the various die parts that are shown in Fig. 1 will be described, but only those features of the other dies which are incorporated for the purpose of performing some special operation will be described. The blanks from which the housings are made are sheet steel, 0.0375 inch thick and 6¾ inches in diameter.

The combination die shown in Fig. 1 forms the shell to the shape shown in the lower part of the illustration. The taper on this shell is started at the very beginning of the forming operation. The design of the die provides for employing the familiar punch press construction, with rubber buffer attachment and supporting plates for pins *P*. The forming die *A* is an integral part of the cast-iron holder, the construction being found very efficient for a preliminary operation of this kind. The punch *B* is also made of cast iron and has a tool-steel ring *C* fitted to its bottom face. The cutting ring *D* is inserted in a recess in the cast-iron die-holder *L*. The flange of the shell is formed and held firmly between the ring *C* and the drawing ring *E* at the completion of the drawing operation. Knock-out pad *F* is used to eject the shell from punch *B* upon the upward stroke of the press.

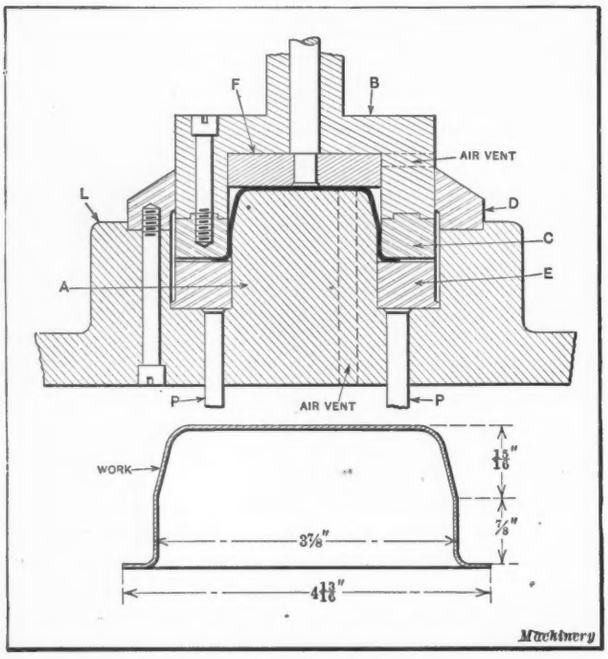


Fig. 1. Combination Die which cuts the Blank and performs the First Drawing Operation

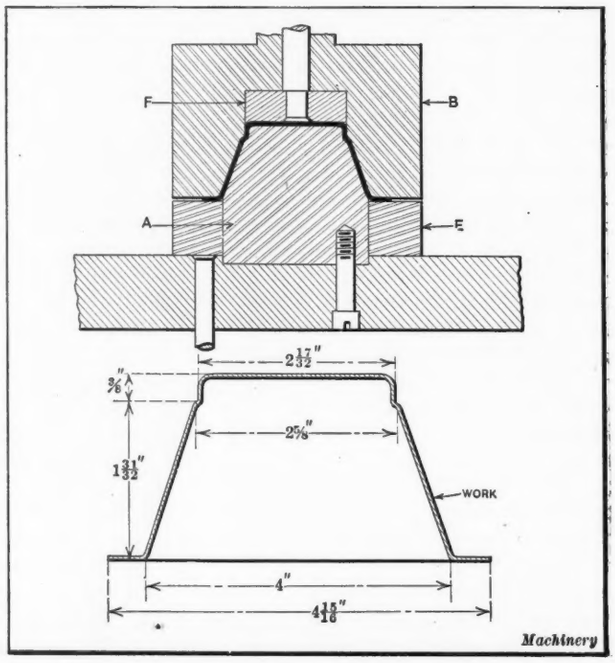


Fig. 2. Die for forming the Tapered Part of the Shell and for the Preparatory Forming of the Small End

The die illustrated in Fig. 2 forms the main or tapered part of the shell and also forms the small end of the shell preparatory to performing the next operation. In its normal position, the ring *E* is raised on the buffer-plate pins sufficiently to allow the flange of the shell to rest upon its top surface, and when in this position the shell is concentric with the forming die *A*. The rubber buffers are screwed up fairly tight during this operation so that when punch *B* descends, the gripping action on the flange will hold the shell securely between punch *B* and the ring *E*, and the shell will not be distorted or changed during the operation of the press. The top part of the shell becomes contracted and the lower part expanded to the shape of the forming die as the punch completes its descent. This method has proved very satisfactory for shaping tapered shells of this type.

The die shown in Fig. 5 is known as a hole and flange die. The forming die *A* has a cutting edge on its inside diameter. The locating ring *G* conforms to the taper of the shell, and is so shaped as to furnish a seat for the flange, the shell thus being located concentrically with the punch. In operation, the cutting punch *H* comes in contact with the shell a trifle ahead of punch *B*, and cuts a hole in its center as it passes the cutting edge of *A*. As *H* continues to descend into the hole in *A*, punch *B* comes into contact with the shell and turns or edges up the shell as shown. This operation completes the small end of the shell.

The blanking die shown in Fig. 3 operates on a rubber buffer, the same as the combination die shown in Fig. 1, and is used for trimming the flange of the shell concentric with the shell itself, which is very essential in work of this type. The pad *J* holds the work and locates it properly in relation to the cutting edge of punch *B*, and also lifts the shell out of the die on the return stroke of the press. It will be noted that there is a space provided between the lower surface of the cutting ring *D* and the pad, which allows sufficient movement of the pad to permit the shell to be readily removed from it. There is another die used in making the muffler housing which is not illustrated, but which is similar in construction to the one shown in Fig. 3. This die is employed to trim the shell flange on one half of the housing ¼ inch smaller in diameter, the purpose of which will be apparent later. Fig. 4 shows a die that turns or edges up the flange of the other half of the housing. The ring *K* is recessed at *R* to suit the diameter of the flange, thus locating the shell properly. The punch *B* descends upon the shell and edges up the flange by pushing it clear through ring *K*, after which the shell drops off the punch and through a hole in the die.

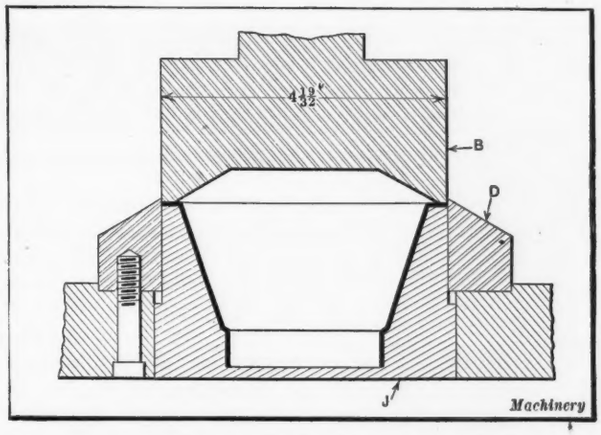


Fig. 3. Blanking Die used for trimming the Shell Flange

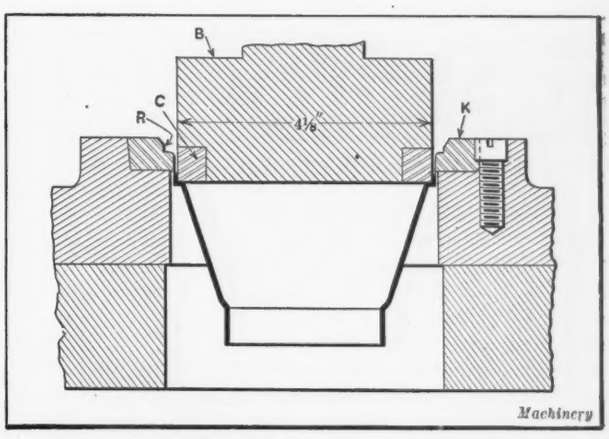


Fig. 4. Push-through Die for turning up the Shell Flange

In the operation illustrated in Fig. 6, one of the shells, which has had the diameter of its flange trimmed ¼ inch smaller than shown in Fig. 3, is placed within the turned-up flange of the other shell which is placed in holder *L*. This die is a plain closing die which is employed to fold the edge on the lower shell over the flange of the upper shell to produce the complete muffler housing. The cast-iron punch *B* has a tool-steel ring or face *C* attached as shown, and is also equipped with a knock-out pad *F*. The tool-steel ring *K* is inserted in the holder *L*, both rings *C* and *K* being hardened and ground to their proper shapes. Dies of this type work very well if properly made, the correct method being to make the inside diameter of ring *C* where it comes in contact with *K*, the same as the inside diameter of the ring *K* in Fig. 4, and the ring *K* in Fig. 6 should be made to fit ring *C* very closely.

* * *

BELGIAN-AMERICAN CHAMBER OF COMMERCE

The Belgian-American Chamber of Commerce, originally organized about twenty years ago, but interrupted in its activities during the war, has just been reorganized, and the secretary, René L. J. De Wael, may be addressed at 4 Montagne du Parc, Brussels. The membership at the present time consists of 60 Americans and 200 Belgians, and the chamber is a member of the Chamber of Commerce of the United States, at Washington. The services rendered by the Belgian-American Chamber of Commerce are being considerably extended and are at the disposal of American firms interested in establishing connections with Belgium.

SALE OF MACHINE TOOLS TO BELGIUM

The War Department has authorized publication of the following statement from the office of the Director of sales: The War Department has entered into a contract with La Construction Metallique, a cooperative society composed of the heads of approximately five hundred industrial organizations of Belgium, for the sale of a quantity of surplus machine tools held by the War Department. The Belgian Government has arranged through American banking interests, for a credit of $50,000,000 in the United States, and La Construction Metallique has been authorized by the Belgian Government to make purchases of machine tools against this credit to the extent of 25,000,000 francs. To date, La Construction Metallique has purchased from the War Department approximately 2500 machine tools. The contract with La Construction Metallique was made by C. W. Hare, Director of Sales, during his recent visit to Europe. La Construction Metallique recently sent to the United States a commission headed by Lieutenant Jean Jean, the Director General of the Cooperative Society, to make a general survey of the mechanical equipment which the bureaus of the War Department hold as surplus. The machine tools sold to La Construction Metallique are now being selected from the several districts of the Ordnance Department, the Air Service, and the Purchase and Storage Service, and are being put in transit to Belgium as rapidly as they can be prepared for shipment. More complete information on earlier Belgian transactions by the Government will be found in the November number, page 226.

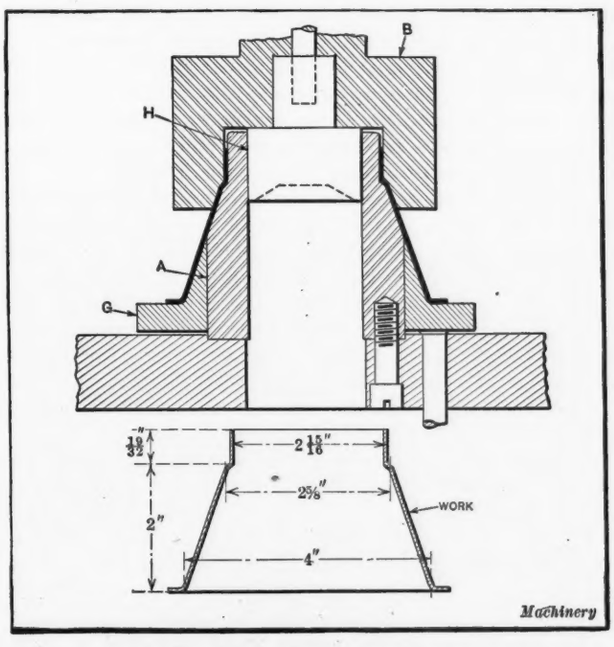


Fig. 5. Hole and Flange Die which cuts a Hole in the Small End of the Shell and turns up the Edge

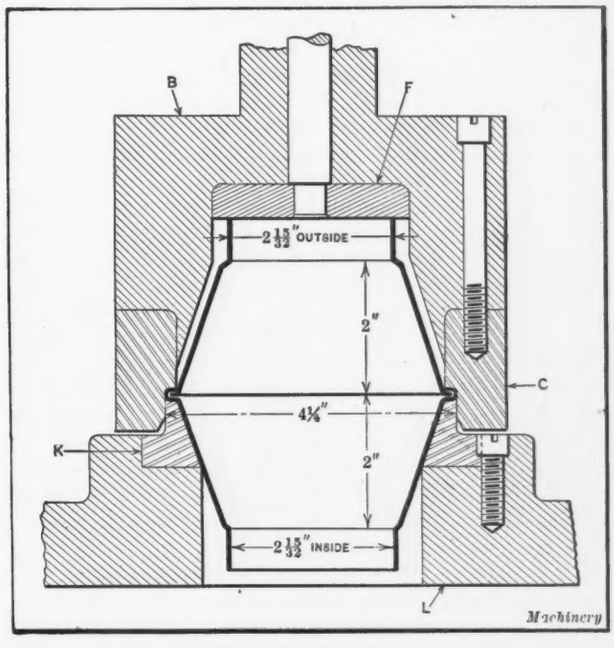
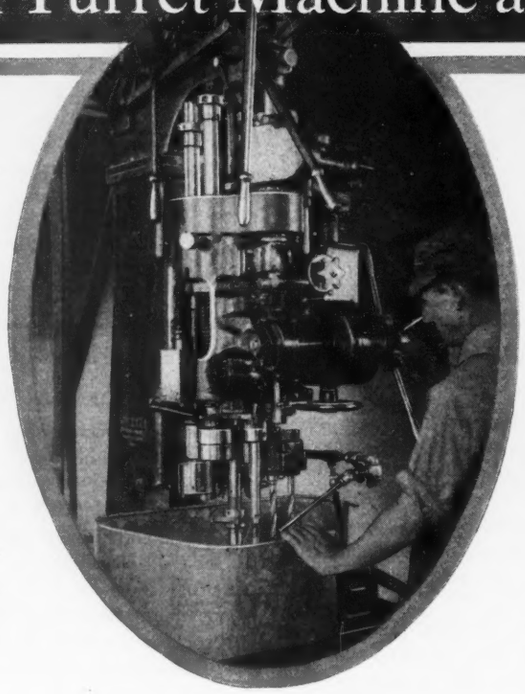


Fig. 6. Closing Die which secures the Two Shells together, producing a Complete Muffler Housing

The Vertical Turret Machine and Its Work



Uses of the Turner Vertical Turret Machine on Quantity Production Work Including a Description of the Equipment Used on Various Machining Operations

By FRED R. DANIELS

MODERN requirements in interchangeable manufacturing necessitate that as much as possible of the work should be performed on one machine and in a single setting of the tooling equipment; otherwise the resulting loss of time caused by changing the set-up and the expense of extra machines will make economical production impossible. Forged and machine steel parts which can readily be handled on automatic chucking machines and turret lathes offer no perplexing problems in this regard, but when such parts are of irregular shape, requiring surfaces to be finished which are not located from a common center line, or axis of rotation, difficulties arise when attempting to machine these parts without excessive handling. In fact, it is generally conceded that for such work special holding fixtures must be employed for machining differently located surfaces. Many such parts are used on automobiles and airplanes, in the manufacture of which, a great variety of bolts, knuckles, and other similar small forgings are required to be machined.

The vertical turret boring and chucking machine is especially adapted to this type of work; and the steel forging shown in Fig. 4, finished in one setting, furnishes a good example of what can be accomplished. With this machine the problem resolves itself into designing a ruggedly constructed indexing fixture and selecting an operator of average ability. The most recent model of the vertical turret machine referred to in this article, known as the Model F Turner vertical boring and chucking machine, is the product of the Turner Machine Co., Danbury, Conn. It is the purpose of this article to deal more especially with the uses of this machine on various classes of work rather than with the construction of the machine itself, except as it may be referred to, incidentally, in order to more clearly describe the machining operations.

The turret of the machine revolves automatically from right to left in a horizontal plane, after each tool has been withdrawn from the work. The turret is gear-driven (see Fig. 1), and provision is made whereby, by means of minor gear changes, the spindles may be independently driven by gears *A*, at different speeds so that no attention need be paid to speeds after the job has once been set up.

The hanger bolt shown in detail in Fig. 4 is typical of the class of work for which the vertical boring and chucking machine is especially fitted. It is a steel forging, 0.30 to 0.40 per cent carbon content, and is machined complete on the turret machine without change of tools. The operations performed on the forging are as follows: Drill one 11/16-inch and one 5/8-inch hole through 1 7/16 inches of metal; rough-turn shank 2¼ inches long and face shoulder; rough-turn shank 1 inch; finish-turn shank 2¼ inches long; thread 5/8-inch diameter, 18 threads per inch; countersink one side of 5/8-inch hole and face adjacent surface. The production time on this job with an operator of only average ability is 5 minutes per piece. One workman can easily operate two machines at a time, taking care of the threading and hollow-milling operations on one machine while the second machine is engaged in drilling the two holes automatically.

Mechanisms for Indexing the Turret

A description of a machine which is similar to that employed in performing the work described in this article was published in the February, 1918, number of MACHINERY. This machine, however, did not possess many of the features incorporated in the more recent model illustrated herewith. In describing the various operations performed on this machine it may be well to refer briefly to the several mechanisms of recent application which are employed to actuate the indexing movement. A toothed clutch on the hub of the foot spider *B*, Fig. 1, operates the vertical traverse of the spindles so that by raising the spindle that is in the operative position, a tapered roller bearing friction clutch *C* is engaged to index the turret *K*, advancing the second spindle into the operating station. The advantage of this means of transmission of power will presently be apparent. Before the turret can be revolved, however, the steel detent, or locking member *H*, must be withdrawn. This is accomplished just before the clutch is engaged, by means of a ratchet and pawl arrangement which is also operated by the upward travel of the spindle. As a result of this device, lever *F* (see also Fig. 8), engages an extending finger *G* and ejects the detent. The details of the clutch and the device employed to support it when disengaged are illustrated in Fig. 3.

The tool steel inner member *A* of the clutch is attached to a bronze sleeve *B*. Three springs interposed between these two members permit a flexible movement and allow the clutch to readily align itself when being thrown into engagement. This inner member has a 3-degree taper and fits into the turret pinion *D* to which is attached a bronze retainer *C* which carries the tapered rollers in suitable conical slots. The double driving gear *E* is attached to the vertical shaft of the machine (see also Fig. 1), and has a tapered chamber, within which the clutch rollers operate, revolving the turret to the next operating station as soon as the clutch sleeve is raised. The action of the driving gear will cause the tapered rollers to immediately roll themselves free from engagement, after the supporting device (shown assembled in the lower right-hand corner of the illustration), has been automatically released. However, the employment of tapered rollers in the clutch and their arrangement in the retainer slots, in combination with the yielding construction of the clutch sleeve, permits the turret pinion *D* (see also Fig. 1), to remain in mesh with the turret gear *J* even when the clutch is disengaged.

The supporting device, except when employed to raise the clutch, is inoperative and supports the clutch by means

of a hook *F*, Fig. 3, which hangs from the inside wall of the turret case. It is actuated by a lug on the upper end of the spindle which is to be indexed. This lug engages the under side of the swinging cam *G* directly after the locking detent has been withdrawn. The turret being now unlocked, the friction clutch is free to act as soon as the spindle has been raised sufficiently to force the cam *G* against latch *H*, so that hook *F* will swing free as the clutch is brought into engagement. As soon as this movement occurs, the swinging cam, by means of the now revolving turret, forces the hook into its upright position and the entire supporting device drops down to normal again, suspended by hook *F*. The part *K* in this illustration is the bronze index-control cam which carries a steel detent socket *L* in which the detent engages to lock the turret. The lug *M* on these cams performs a very important function in the cycle of movements connected with indexing the turret. These cams are spaced around the periphery on the under side of the turret, the location and quantity corresponding to the number of spindles in the turret. The arrangement is quite plainly shown in Fig. 2, in which the cam and the lug are designated by the same reference letters that are employed in Fig. 3.

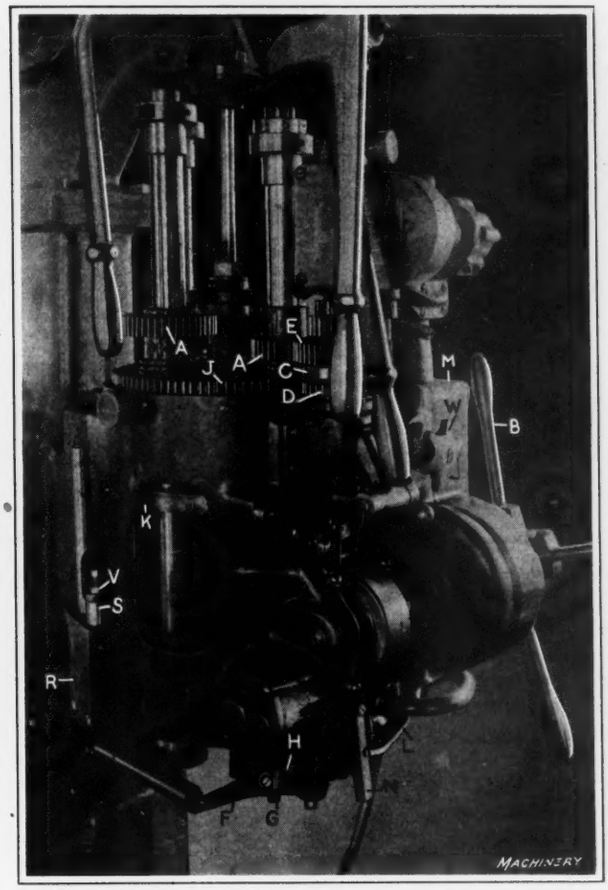


Fig. 1. Vertical Turret with Top Gear Guard removed showing Indexing Gears and Clutch Drive

Referring to Fig. 1, the opposite end of the lever *L* (which might be termed an escapement lever), is swung outward as soon as the friction clutch has started to revolve the turret, through the agency of the lug on the particular index-cam that is located nearest the advancing spindle. This results in operating lever *N*, releasing a catch and allowing the detent to spring into its socket in the bronze cam. Ordinarily a rather severe shock would attend the action of this indexing mechanism if some form of check were not provided to absorb this shock. Accordingly, the Turner turret Model F machine is equipped with an oil-pressure hydraulic brake, or shock absorber *R*, Figs. 1 and 2. The plunger *S* carries a shoe *T* at its lower extremity, which is operated against the hydraulic pressure by the lug on the index-control cam which is located near the receding spindle, that is, near the spindle which has just left the operative position. The operation of the shock absorber is so timed by its location in relation to the cams, that the stopping of the heavy turret is accomplished without severe shock to the machine. The oil pressure is regulated by means of valve *V*. The machine is also equipped with a feed mechanism, automatically regulated which may be engaged or disengaged while the machine is in operation. The feed-gears provide four feed changes without regard to the spindle speeds and are enclosed within case *M*, Fig 1. Change of feeds is accomplished by adjusting hand-wheel *W*.

With the foregoing brief description of the construction of those devices which concern the actual indexing of the turret, a better conception can be had of the use and manipulation of the machine when employed on quantity production. A few representative examples of vertical turret machine work will now be described in detail.

Machining a Front Spring Hanger Bolt for Automobiles

In discussing the performance of work required to machine the automobile hanger bolt shown in Fig. 4, attention is called to the tooling lay-out shown in this illustration which furnishes a graphic presentation of all data necessary to enable the reader to readily understand the arrangement of the set-ups and the sequence of operations. Fig. 8 shows the piece clamped in the fixture preparatory to performing the first operation—that of drilling the two large holes. After the fixture has been indexed 180 degrees, the turret is indexed to No. 1 spindle, bringing the duplex drill head into the operating position. Fig. 9 shows the operation in the course of completion.

After these two holes have been drilled, the work is indexed 90 degrees and the turret indexed to No. 2 spindle where the second operation, which consists of rough-turning the large diameter and facing the shoulder, is performed. The tool used for this operation is an ordinary hollow-mill (see Fig. 10). Following this operation, the turret is in-

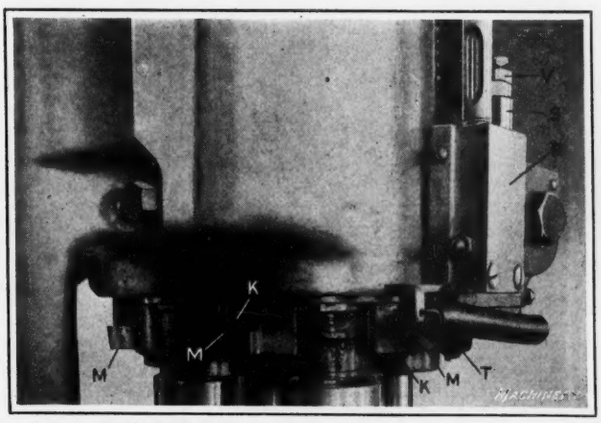


Fig. 2. Arrangement of Index-control Cams on Under Side of Turret

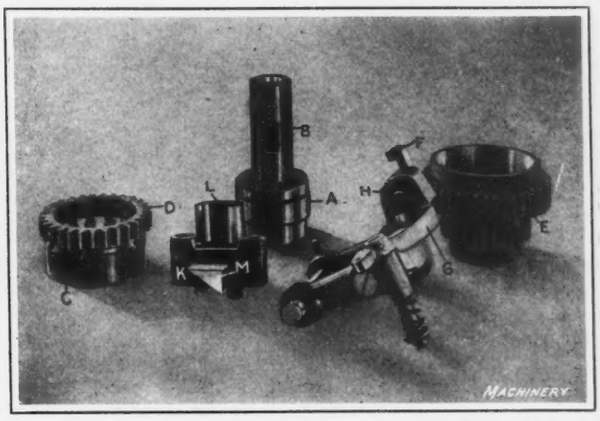


Fig. 3. Clutch Parts and Index-control Cam with Detent Socket

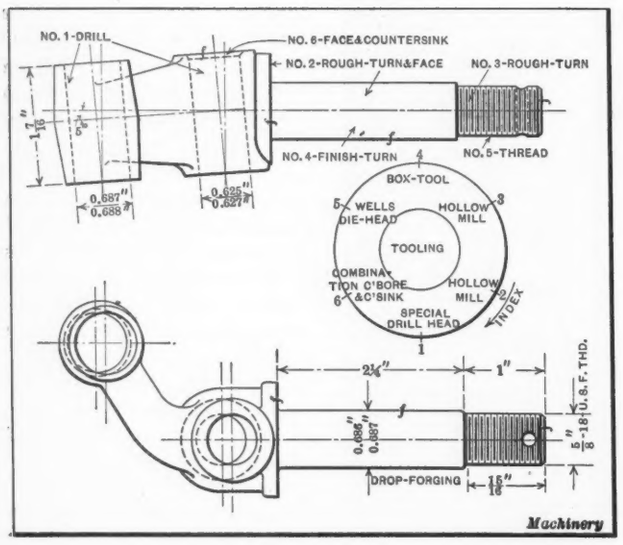


Fig. 4. Detail of Front Spring Hanger Bolt for Automobiles, and Tooling Lay-out

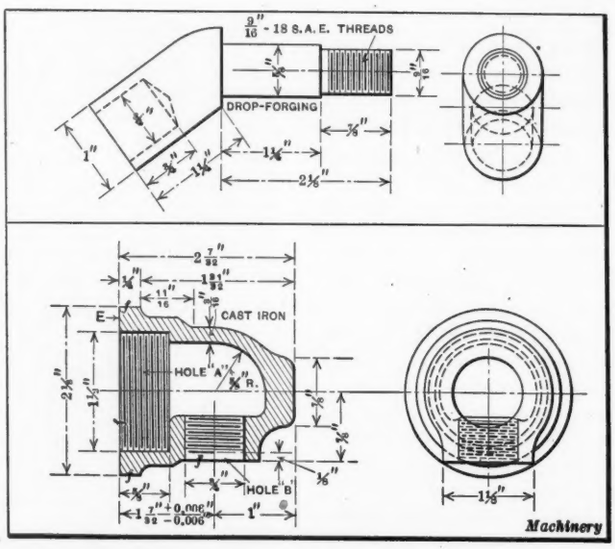


Fig. 5. Additional Examples of Vertical Turret Machine Work, and Operations performed on Each

dexed to No. 3 spindle where the ⅝ inch diameter is rough hollow-milled to a length of 1 inch. Operation 4 consists of finish-turning the large diameter to the dimension shown in the illustration after the turret has been indexed to No. 4 spindle. This operation is illustrated in Fig. 11 from which it will be seen that a box-tool of the usual type is employed. The next operation, the fifth, which is shown in Fig. 12 consists of threading the ⅝-inch diameter end of the forging, 18 threads per inch, and is performed on spindle No. 5 with a Wells self-opening die-head, the opening cam or yoke trip *A* being located on the center post *B*. The arrangement may also be clearly seen by referring to Fig. 7 which shows the position of the die in engagement with the opening cam *A* after the completion of the threading operation. The sixth and last operation is performed on spindle No. 6 after the fixture has been indexed another 90 degrees. This brings the work into the starting position, shown in Fig. 8, where the surface around the ⅝-inch hole is faced and the hole countersunk, the tool used being a combination counterbore and countersink. This completes the work and the finished forging is removed from the fixture, another clamped in place, and the fixture indexed 180 degrees before again indexing the turret. It will be noticed that a cotter-pin hole is drilled through the threaded end of the bolt. This is done by the operator on a small drilling machine located near the turret machine, during the time the large drills are feeding through the next piece; thus the idle time of the operator is greatly reduced. For the drilling operation, a special duplex drill head is employed, the detailed construction of which is shown in section in Fig. 7. The head, which is a very simple design, consists essentially of an auxiliary spindle *B* driven by gears from the main spindle *C* (see plan section view through gear head). Both spindles, as will be clearly seen in the illustration are provided with ball thrust bearings. The case *D* which encloses the head has a removable cover *E* and a radial arm *F* which connects with a center post—a provision for counterbalancing the overhanging weight of the drill head, preventing sag and consequent inaccuracy.

The work-holding fixture used on this job is illustrated in Fig. 6. Its principal feature, which is also common to all jigs used in vertical turret machine practice, is that it is of a very rugged and simple construction. The fixtures must be rugged in order to permit positive clamping and indexing arrangements for firmly holding the work under the severe strains which are commonly produced in this general type of machine operations. The outer jaw *A* of the fixture is turned to fit a bearing in the base *B*, and extends far enough beyond the bearing to allow a thrust collar *C* and a handwheel *D* to be assembled. The opposite end of this jaw has a journal by means of which it is mounted in the block *E*, on the base. The inner jaw *F* is the movable member and functions through a hole in the outer jaw, being closed on the work through the medium of the cam lever *G* operating the cam *H*. This cam compresses spring *J* so that when released by the cam lever, it will force the jaw

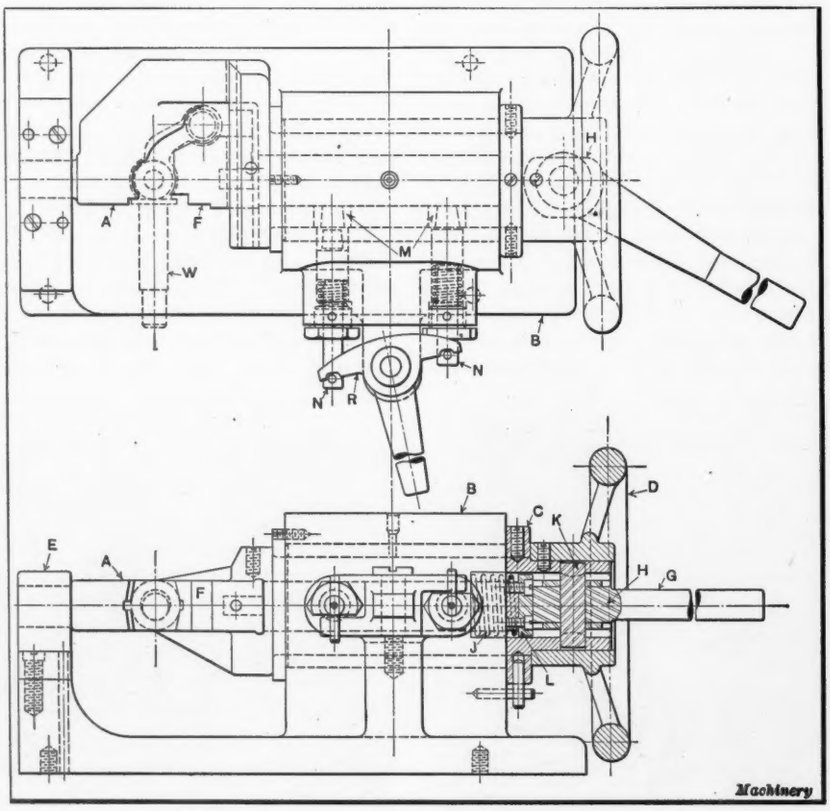


Fig. 6. Fixture for holding Automobile Hanger Bolt when machining on the Vertical Turret Machine

open and permit the work *W* to be removed. It will be seen that the cam is hung on a pin *K* within the bore in the end of the outer jaw, and that when it is in engagement with head *L* of the inner jaw, the entire clamping arrangement and the work may be revolved by turning handwheel *D*. The proportions of the lever *G* are such as to enable it to be used to advantage when revolving the fixture by producing greater leverage than could be obtained with the handwheel alone. Bushed index holes *M* in the outer jaw bearing permit the fixture to be indexed in the desired position by means of spring-actuated detents *N* operated by the rocker arm *R*. The two detents shown in this illustration, permit the use of the fixture for either right- or left-hand hanger bolts.

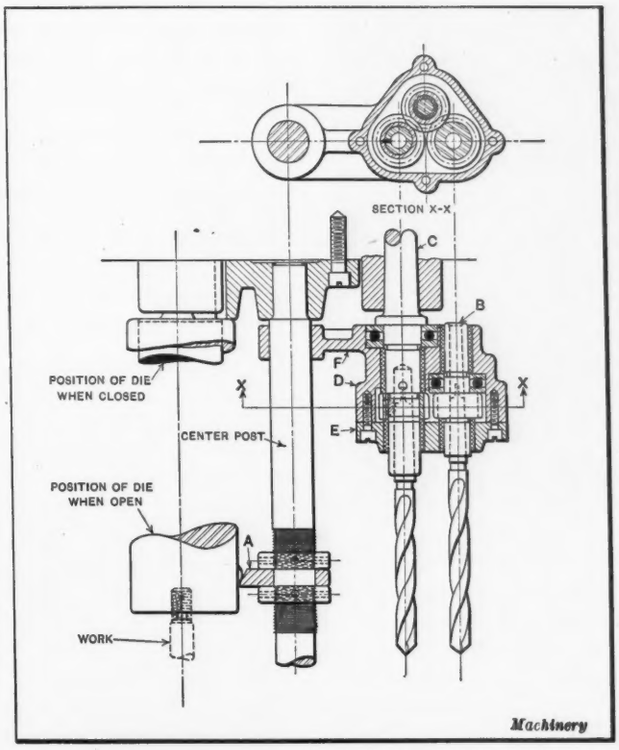


Fig. 7. Duplex Drill Head with Sectional View through Gears. This Illustration also shows Position of Die-head when in Engagement with Opening Cam

Since the general character of the work performed on the vertical turret machine and the methods and tools employed in the performance of the operations should be well understood from the foregoing description, only a comparatively brief description will be given of additional examples of work which may be advantageously handled on this machine. In the upper half of Fig. 5, there is shown a working drawing of a small drop-forging which is machined in four operations on a four-spindle machine. It will be remembered that the operations performed on the hanger bolt, previously described, were handled on a six-spindle machine. A ¾-inch hole is first drilled to a depth of ¾ inch. The fixture is then indexed so as to bring the part of the piece which is to be turned into an upright position, after which the turret is indexed to No. 2 spindle for hollow-milling the ⅝ inch diameter and then to No. 3 spindle for hollow-milling the 9/16 inch diameter. The fourth operation on the forging consists of threading the 9/16 inch diameter, 18 S. A. E. standard threads per inch on the No. 4 spindle. The total time for finishing the piece is 3½ minutes. Since the tooling arrangement does not involve the use of special equipment, no further information other than that contained on the illustration should be necessary.

The cast-iron fitting shown in the lower part of Fig. 5 is finished in two settings of the turret machine. The operations performed in the first setting are: (1) Bore hole *A* ⅝ inch deep; (2) face end *E* of casting using a pilot counterbore; (3) turn 2⅛-inch flange, with a box-tool; and (4) tap hole *A* 10 threads per inch (collapsible tap). The second series of operations concerns the machining of hole *B* in the following sequence: (1) bore; (2) face (counterbore); (3) counterbore ¾ inch diameter, ⅛ inch deep; and (4) tap hole *B*, 14 threads per inch. The total time for both series of operations is 5 minutes, 3 minutes for the first setting and 2 minutes for the second setting.

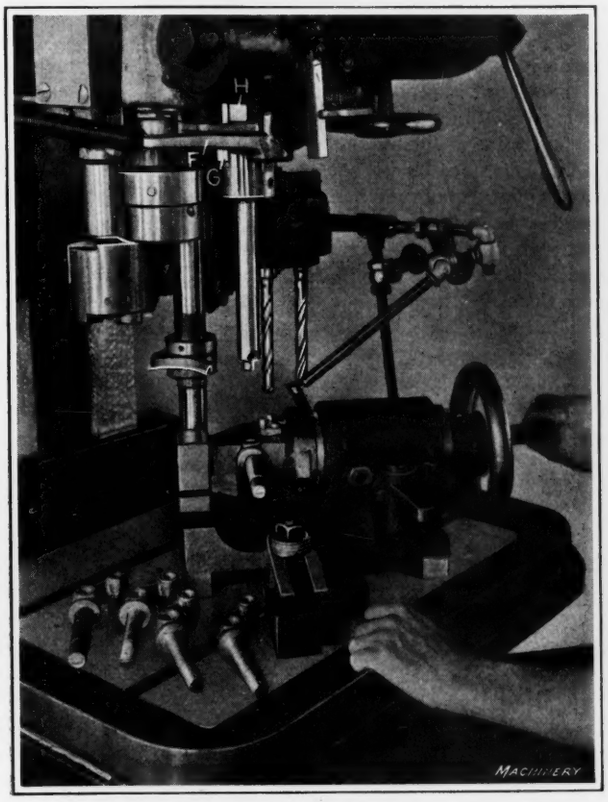


Fig. 8. Hanger Bolt clamped in Fixture before indexing Either Fixture or Turret

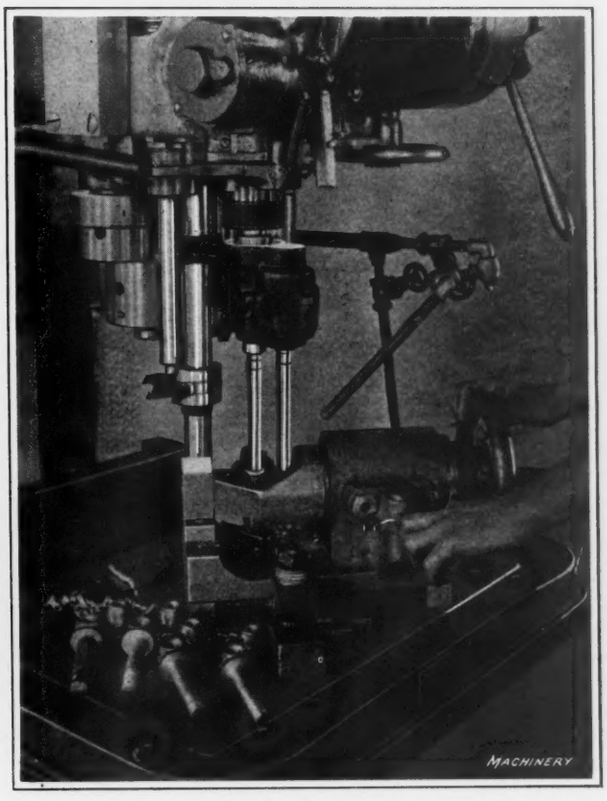


Fig. 9. After indexing Fixture and Turret. Drill Head at Work on First Operation

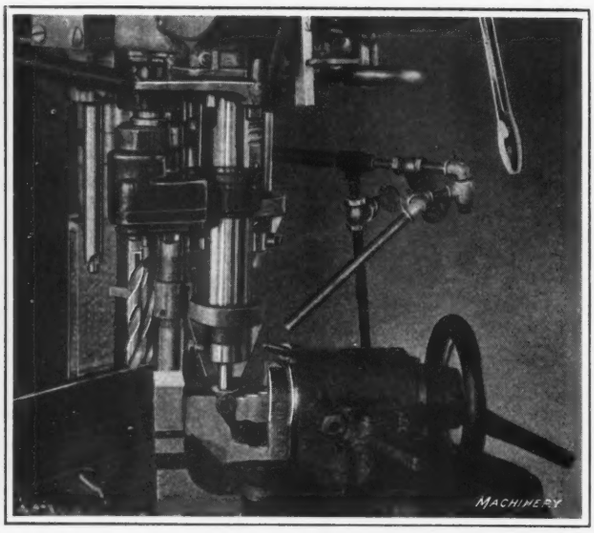


Fig. 10. Second Operation consists of rough-turning Large Diameter of Body and facing Shoulder with Hollow-mill

Machining Automobile Steering Knuckles

Another automobile part, large quantities of which have been entirely machined on the Turner vertical turret machine, is shown in detail in Fig. 14. The part is a forged steel steering knuckle for automobiles, the machining of which was performed on a four-spindle, instead of a six-spindle machine. Consequently, and also on account of the large number of operations required to finish the part, it was found necessary in this case to make three separate set-ups in the completion of the job. The tooling lay-out for each of these set-ups is presented in diagrammatic form in Fig. 15. The 43/64-inch hole is first drilled half way through the forging and the end faced, as shown. This requires the use of the first two spindles, after which the work is revolved 180 degrees and the third and fourth operations performed in a similar manner on the opposite end.

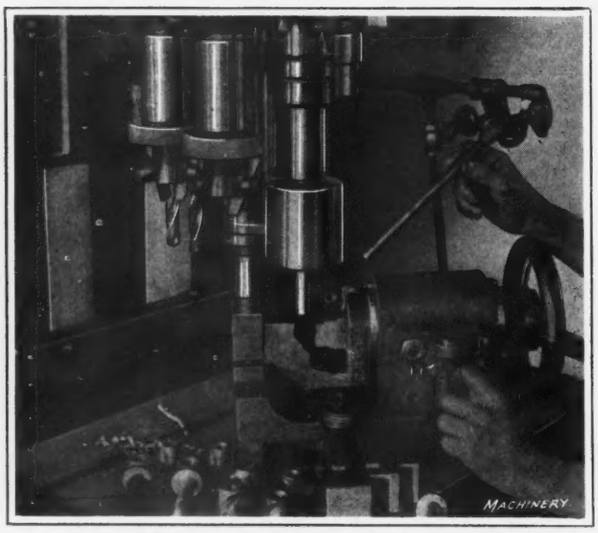


Fig. 11. Performing the Fourth Operation which consists of finish-turning the Large Diameter of Hanger Bolt Body using a Box-tool

This last facing operation establishes the 4⅜-inch length of the bearing end of the knuckle. On account of the length of this hole, more accurate results are obtained by drilling in from each end to the center line than could be had by running the drill entirely through, which would probably result in the drill running out considerably before finally breaking through at the opposite end. The second series of operations performed on the knuckle, consists of drilling and reaming the ¾-inch hole; facing both sides of the boss through which this hole is drilled; and finally countersinking the hole ⅛ inch deep.

The operations performed during the third set-up, as will be seen by inspecting Fig. 14, are those confined to the shafting part of the forging, on which the front wheel of the automobile is assembled. The first operation consists of hollow-milling the threaded end to a length of 2 inches and to a diameter of 0.749 inch. Operation 2 is also a hollow-milling operation, the large diameter being turned to a dimension of 1.1875 inches. The third operation consists of removing the burr formed in the first operation at the intersection of the tapered section with the straight turned end. A chamfering tool is employed for this operation. The work is finally completed on the fourth spindle by threading the ¾-inch end, 16 threads per inch, (S.A.E. standard). The production time for the three settings is 5½ minutes.

If a six-spindle machine had been used on this job in connection with an indexing fixture, it would have been a simple matter to arrange the work so that the eight operations included in set-ups Nos. 1 and 3, Fig. 15, could have

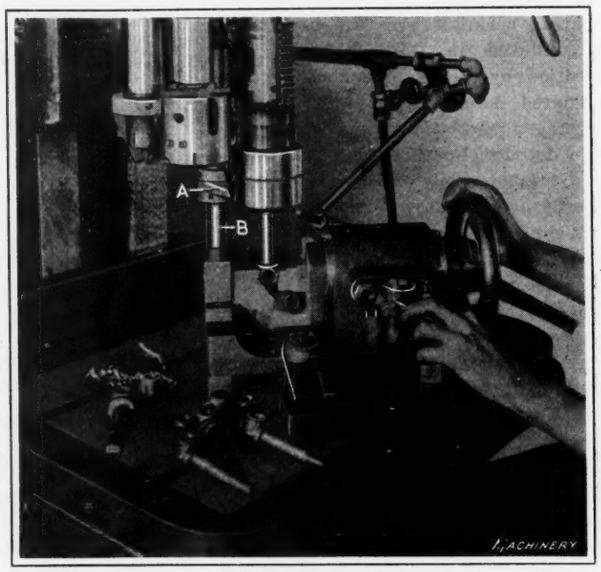


Fig. 12. Operation 5—Threading the End of Body with Wells Self-opening Die-head

been performed in one setting of the tools. This would permit the performance of those operations now included in the second set-up, to have been done on another machine during the time required to drill the 43/64-inch hole, thereby somewhat reducing the production time, although tying up two machines on the job in so doing. It is safe to state, that to the average mechanic the machining of this forging would doubtless present difficulties, the solution of which might require the design of elaborate fixtures, or in any event, the use of two or more machines, the employment of more than one operator, and a considerably increased amount of handling, which, of course, means a decreased production rate.

In connection with the reference to quantity production, it may be well to emphasize the need for a machine of the

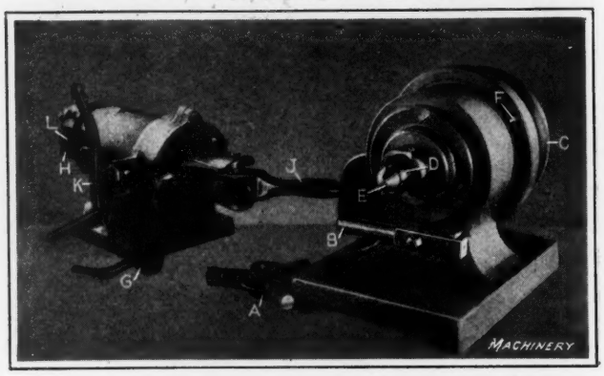


Fig. 13. Typical Work-holding Fixtures used on Vertical Turning and Boring Operations

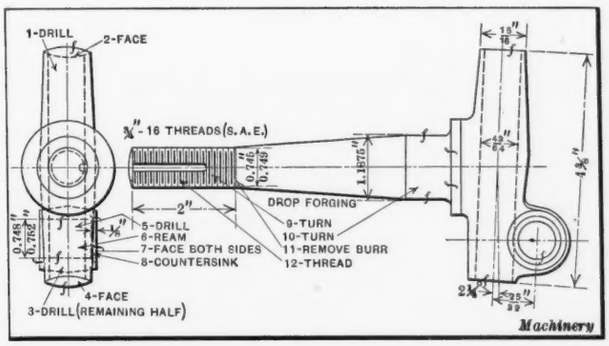


Fig. 14. Working Drawing of Automobile Steering Knuckle showing Various Operations

vertical turret type containing gang or multiple turrets, after the general design of the multiple-spindle vertical drilling machines. Such a machine, equipped with two or even three turrets, would be the means of greatly augmenting the present high productivity of vertical turret machines without employing additional operators. An arrangement of this kind is altogether feasible and offers an opportunity for spindle arrangement and timing for each turret whereby continuous production could be maintained. In view of the fact that continuous output is obtained by the adaptation of this principle in such shop tools as drilling and milling machines, this suggestion is only a natural conclusion and is, no doubt, within the limitations of the adaptability of vertical turret machines.

Fixtures Used on Vertical Turret Turning and Boring Operations

Emphasis has already been laid upon the fact that the principal features of the fixtures and jigs employed in the vertical turning and boring practice are simplicity in design and ruggedness of construction. These two characteristics are apparent from the illustration, Fig. 13, which shows two fixtures that have been used on the Turner turret machine for quantity-production work. The fixture at the right in this illustration is used in machining the differential spider shown at *A*. Three turning operations are performed on each of the three arms of the spider, consequently an indexing plunger or detent is employed to lock the work-holding fixture, at every 120-degree revolution of the work. This detent is operated by means of handle *B*, and the fixture is revolved by handwheel *C*, which when the fixture is locked, also operates a draw-in chuck, by means of which the work is secured in place. One of the three index-holes in which the detent fits when indexing the fixture is shown at *F*. The forging is slipped on the split sleeve or collet *D* which normally is a loose fit within the hole in the spider hub; then by turning the handwheel the tapered pin *E* within the collet is drawn in, thereby expanding the collet and securely clamping the work. The time required to perform the nine operations on the spider including indexing, is five minutes.

The other jig shown in the illustration is employed to hold the small drop-forged arm *G* during the various operations performed on the stem, hole, and hub of the piece.

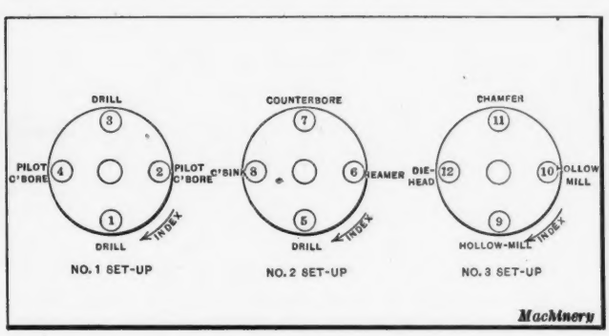


Fig. 15. Tooling Lay-out for Forging shown in Fig. 14, illustrating diagrammatically, the Sequence of Operations

The work is held between two jaws, the outer one of which *H* has a groove *L* shaped to conform to the offset of the arm. The jaw is operated by a toggle-jointed handle *J*, which also, by means of this joint, produces a positive clamping action. This fixture is also indexed 90 degrees after machining the stem, bringing it in position for finishing the hub and hole. The index plunger is controlled by handle *K*.

It will be observed that owing to the design of those parts which are especially suitable for finishing on the vertical turret machine, that an indexing device is, in nearly every case, employed in the fixture as a means of presenting the various surfaces of the work to the tool without removing the piece from the fixture. The advantage of employing indexing fixtures to eliminate repeated handling of the work, makes vertical turning and boring practice distinctly a quantity production method of machining.

* * *

A LIVE-WIRE MACHINE-SETTER

By J. J. BORKENHAGEN

In changing over a small automatic screw machine department from a day-rate basis to a premium system, a premium rate was set for all pieces over and above 85 per cent production, the other 15 per cent being an allowance for stocking up the machine. On the basis by which the rates were set, the operators could, by obtaining 100 per cent production, make approximately 40 per cent over the regular day rating. Under this arrangement the machine-setter's share of the premium earned was 30 per cent; the two operators' share, 25 per cent each; and the share for the helper, 20 per cent. The machine-setter took full advantage of the possibility presented in the arrangement, and after the system had been in use for a few days, it was noticed that he was timing each machine with a time-study watch. Upon being asked the reason for using the watch, he replied that he was going to make the machine "talk 100 per cent to me." He had observed that a slipping belt, or an incorrectly adjusted part, such as a feed-cam, was retarding his production and beating him out of his premium money. This was the reason for using the watch, and explained why he had gone to the expense of buying it with his own money. It is needless to say that this man and the operators under him always made premium wages. The machine-setter also used a card system, showing the feed, speed, cams, rate of production, actual time in seconds per piece, and such other data as might enter into the problem of obtaining 100 per cent production.

* * *

THE CALIPER AS A CHECK FOR MICROMETER MEASUREMENTS

By DONALD A. HAMPSON

For experimental and maintenance work in which only a few pieces of a kind are required at a time, limit gages are not usually supplied. Mistakes in reading the micrometer are of quite frequent occurrence on such work, and invariably these mistakes are not errors in reading the graduations on the thimble, but rather in reading from the wrong 0.025 line. In the effort to make a close fit, workmen are likely to pay more attention to the graduations on the thimble between which they must work, than to the lines indicating the number of turns of the thimble. From this it will be apparent that the caliper serves as a good check for obviating an occurrence of this sort. The micrometer cannot, of course, be safely used on work that is revolving in the lathe, nor is it the proper instrument for measuring roughing cuts. It is not difficult for mechanics to work within a hundreth of an inch, using the scale and caliper, and it is without doubt the quickest method for ordinary machine work and for roughing.

Future of Machine Trade with South America

A GREAT deal has been said about the possibilities for future trade with South America, as regards both machine tools and woodworking machinery. An analysis of the past trade with the South American countries, therefore, will prove of interest, and the accompanying tables have been abstracted from reports published by the Bureau of Foreign and Domestic Commerce, Washington, D. C., in order to show the amount of the trade in machine tools and woodworking machinery previous to and during the war. Table 2 gives the amount of metal-working machinery, including machine tools, exported annually from the United States to South American countries, from 1909 to 1918, inclusive. Table 1 gives the amount of machine tools exported during 1918, which is the first year during which machine tools were separately classified in the government statistics. Table 3 shows the amount of woodworking machinery exported annually from 1912 to 1918, not including sawmill machinery, while Table 4 gives figures for sawmill machinery.

Previous to the war, a large proportion of the metal-working machinery imported to South American countries came from England and Germany. The total amount of metal-working machinery exported annually during 1912, 1913, and 1914 from the United States to the South American countries averaged about half a million dollars. During the same three years our exports to France alone averaged more than three times that amount, and our exports to Belgium alone averaged over 30 per cent more than our total exports in metal-working machinery to all the South American countries combined. This would indicate that the South American market had considerable limitations as compared with the markets of the European countries. In 1912, our South American trade in metal-working machinery was less than 5 per cent of our total exports. In 1913, it was not much more than 3 per cent, and in 1914, less than 3 per cent of our total exports.

During the two last years of the war, however, the value of the exports of metal-working machinery to the South American countries increased considerably, as will be noted from the tables, but the increase was not proportionate to the increase of our foreign trade elsewhere. In 1917, for example, our South American trade in metal-working machinery was not quite 1 per cent of our total foreign trade in that line, and in 1918, when our exports to the European countries were considerably curtailed on account of the United States having entered the war, while at the same time our South American trade almost doubled, the South American buying still amounted to only a little over 5 per cent of our total exports, and to less than ½ per cent of our estimated production of machine tools alone in that year.

Attention is called to these facts merely in order to indicate that as yet the South American market in machine tools and metal-working machinery is an insignificant one as compared with the big markets of Europe, and that while it is a market not to be ignored, it is not one on which big hopes can be built for immediate results.

TABLE 1. MACHINE TOOLS EXPORTED TO SOUTH AMERICAN COUNTRIES DURING 1918—VALUE IN DOLLARS

Exported to	All Classes of Machine Tools	Lathes Only	Grinding Machines Only
Argentina	93,227	29,228	9,397
Bolivia	11,437	5,672	252
Brazil	94,590	53,939	7,099
Chile	232,974	125,940	17,920
Colombia	9,276	3,748	1,213
Ecuador	12,992	1,070	294
Guiana, British	9,071	7,394	182
Guiana, Dutch	446		76
Paraguay	13,767	86	8,844
Peru	55,110	29,980	5,911
Uruguay	8,175	1,306	702
Venezuela	11,466	7,091	419
Total	552,531	265,454	52,309

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Woodworking Machinery

With regard to woodworking machinery, the conditions are somewhat different. During 1912, 1913, and 1914, the average exports of woodworking machinery, exclusive of sawmill machinery, into the South American countries averaged slightly over $140,000 a year, which was about 9 per cent of our total exports of this class of machinery during these years. In sawmill machinery, a large bulk of our exports went to the South American countries, or nearly 25 per cent in 1912, 15 per cent in 1913, and over 10 per cent in 1914, indicating that our market in South America for this line of machinery is doubtless better than for metal-working machinery. The machine industries in the South American countries are not highly developed, the main uses for machine tools being in repair and railway shops.

It has also been pointed out that while many native industries exist in the South American countries, most of the industrial and commercial enterprises in the mechanical lines are under the control of foreigners, Europeans of many nationalities having colonized in South America, while the Americans there are few and scattered. It is but natural that concerns of European origin purchase their supplies

TABLE 2. METAL-WORKING MACHINERY EXPORTED ANNUALLY FROM THE UNITED STATES TO SOUTH AMERICAN COUNTRIES, 1909-1918—VALUE GIVEN IN DOLLARS

Exported to	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918
Argentina	72,871	237,123	88,155	117,061	112,747	109,836	25,700	142,907	154,581	166,041
Bolivia	61			5,937	187	9,896	291	56	1,725	15,679
Brazil	23,063	19,657	128,454	331,422	346,187	115,974	55,106	29,606	55,409	164,587
Chile	112	29,302	24,649	59,662	43,930	85,168	28,430	58,447	426,980	792,882
Colombia	3,462	1,240	7,795	1,939	8,967	16,838	11,572	9,488	20,859	17,087
Ecuador	815	2,006	1,054	13,659	510	5,077	3,567	2,972	16,700	14,307
Guiana, British	89	1,316	1,668	242	206	61	163	367	3,191	12,602
Guiana, Dutch			700						916	446
Guiana, French	991	72								
Paraguay						237				14,036
Peru		2,399	6,926	15,073	40,651	35,294	31,631	30,151	71,477	77,964
Uruguay		11,193	5,515	19,305	13,828	20,612	1,845	5,382	27,162	29,281
Venezuela	11,909	761	4,100	2,941	4,706	4,950	6,975	7,080	17,365	25,581
Total	113,373	305,069	269,016	567,241	571,919	403,943	165,280	286,456	796,365	1,330,493

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and machinery in and through their home countries, and for that reason there will be a tendency for a large share of the trade to revert to Europe as soon as the trade channels are again opened and conditions become normal.

At the same time it must be remembered that the South American countries, and particularly the Argentine Republic, are at the present time heavy exporters of food stuffs to Europe, which builds up a favorable balance in their favor with the financial institutions there. Argentine is the only country in the world where the exchange is above normal compared with the value of the currency of all other nations, and this naturally will influence the tendency toward importation of machinery from Europe. Hence any development of the South American market will require exceedingly hard, conscientious and careful work, and it is not a market that will come to us without effort, nor one where great immediate results may be expected.

TABLE 3. WOODWORKING MACHINERY EXCLUSIVE OF SAWMILL MACHINERY EXPORTED ANNUALLY TO SOUTH AMERICAN COUNTRIES, FROM 1912 TO 1918, INCLUSIVE—VALUE IN DOLLARS

Exported to	1912	1913	1914	1915	1916	1917	1918
Argentina	15,515	24,477	14,430	5,074	6,405	37,596	46,979
Bolivia	375	464	950	471	27		5,612
Brazil	72,593	58,526	19,544	8,328	4,159	12,573	8,715
Chile	53,993	39,799	28,049	7,321	5,159	6,970	31,947
Colombia	7,855	1,172	2,061	4,437	1,737	4,868	3,519
Ecuador	64	1,737	2,047	531	2,376	2,250	7,713
Guiana, British	1,451	283	402		12	1,806	1,357
Guiana, Dutch				379		22	
Paraguay			342		429		6,612
Peru	12,203	6,133	30,286	5,069	5,809	6,811	3,466
Uruguay	12,279	6,590	2,528	882	787	165	2,235
Venezuela	5,077	4,947	1,909	581	4,580	13,379	1,311
Total	181,405	144,128	102,548	33,073	31,480	86,440	119,466

Machinery

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CANADIAN ENGINEERING STANDARDS ASSOCIATION

An association for furthering standardization in the engineering trades has been formed in Canada, known as the Canadian Engineering Standards Association. This association has been formed with the object of carrying out in Canada, for the benefit of Canadian industries, work similar to that done in England by the British Engineering Standards Association, and recently begun in the United States by the Engineering Standards Committee formed under the auspices of the large national engineering societies. The Canadian association is supported by contributions from various engineering and industrial societies, as well as from individual firms, and also receives an appropriation from the Canadian government.

The method in which the work is carried out is as follows: When a request or suggestion is received from some responsible firm or person to the effect that the formulation or revision of a Canadian standard is desirable, the association confers with the various interests likely to be affected by the establishment of such a standard, and arranges for the organization of a committee to consider the matter. This committee includes representatives of both the producers and users of the standard in question, together with such technical advisers as may be considered desirable. The committee so formed recommends the adoption or modification of a standard, and its findings are reviewed by the association, the main committee of which must be thoroughly satisfied that full consideration has been given to the subject before it authorizes publication by the association. The actual discussions as regards technical details are thus carried out by specially chosen representatives of the manufacturers and purchasers, and the various interests, whether of the producer, the user, or the engineer, are safeguarded, since all these parties have a voice in the decisions reached. In this way it is clear that before a report defining a Canadian standard is issued or modified, the effective approval of all concerned will have been obtained.

* * *

PRACTICE IN MAKING ENAMELED CAST-IRON WARES

The Bureau of Standards has published a report dealing with the materials and methods used in the manufacture of enameled cast-iron wares. It is the first publication dealing fully with this subject in any language. It deals particularly with the coating of cast iron with white vitreous enamels by the American or dry-powder process. In this method of manufacture, the thoroughly cleaned castings are painted with a suspension in water of powdered glass, clay, and other materials. This suspension is known as the ground coat. The castings are then heated until the ground coat is thoroughly fused, forming an extremely thin layer of transparent glass on the castings. The ware is then withdrawn from the furnace and immediately coated by means of long-handled sieves with a layer of white, opaque, powdered glass, known as the cover coat enamel. Next the castings are returned to the furnace, and in a couple of minutes the cover coat enamel fuses to a smooth layer. Two such layers of cover coat enamel are usually applied, giving a total thickness of from 1/32 to 1/16 inch. The treatise does not discuss the enameling of cast iron with wet coat cover enamels.

Several sections are devoted to a discussion of the preparation and testing of the various chemicals and minerals used in compounding enamels and to the effect each of these has on the physical and chemical properties of enamels. The methods employed in making and cleaning the castings are described in detail, beginning with construction of patterns and ending with sand-blasting and polishing. The methods and equipment, including furnaces, used in preparing enamels and applying them to castings are covered in two sections. Sections are also devoted to the control of the luster of enamels, and to the methods to be used in avoiding blisters, pin holes and other minor defects. Typical formulas are given for ground coat enamels, cover coat enamels containing oxide of tin, and for those containing antimony compounds as the opacifying agent. The calculations that are involved in arriving at each form of expression are explained in detail in the treatise.

TABLE 4. SAWMILL MACHINERY EXPORTED ANNUALLY TO SOUTH AMERICAN COUNTRIES, FROM 1912 TO 1918, INCLUSIVE—VALUE IN DOLLARS

Exported to	1912	1913	1914	1915	1916	1917	1918
Argentina	4,405	4,663	3,707	192	1,414	4,366	343
Bolivia	15				23	35	1,600
Brazil	44,168	62,370	14,576	4,748	20,289	4,100	15,462
Chile	125,731	37,099	24,147	2,040	3,757	2,845	5,001
Colombia	9,083	2,893	7,138	5,190	3,688	5,251	1,599
Ecuador	1,234	247	1,702	655	1,827	999	351
Guiana, British	231	45	2,259	2,596	1,394	1,707	1,629
Guiana, Dutch						3,345	
Guiana, French				78			
Peru	3,587	6,336	3,155	286	2,893	6,756	2,787
Uruguay			471	506		38	445
Venezuela	20,594	9,010	11,829	1,231	3,994	7,876	3,834
Total	209,048	122,663	68,984	17,522	39,279	37,318	33,051

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INCREASED PRODUCTION A NECESSITY

The abnormal decline in foreign exchange, especially with England, France, and the Scandinavian countries, will shortly exert a profound influence upon the trade of the world. With the value of the pound sterling 20 per cent below normal, the franc worth about 9 cents, and Scandinavian money depreciated 25 per cent, it will evidently become increasingly difficult to sell our products in those countries. European economists and manufacturers are quick to see and to utilize the advantage these conditions create for them. If the present abnormal exchange rates continue in effect for an appreciable period there will be a reversal of the trade currents. Already French and English makers of high-speed and tool steels are planning to sell their products in the United States on a larger scale than formerly, and one large English machine tool builder has entered the American market with the intention of permanently establishing a business here. Scandinavian manufacturers of various products and accessories are making plans to enter our markets, and doubtless this competition will be felt in certain lines within a few months.

Some think the easiest way to meet this competition is by increased tariffs; but while this will be helpful, it is only a temporary and artificial remedy. Increased production is the fundamental necessity. The workers of the United States should realize that if they persist in shortening the working day and decreasing production, all our industries will suffer, our foreign trade in manufactured products will disappear, and masses of workers will find themselves out of employment. If they want hard times, shorter hours and increased pay under present conditions will bring them. Prices cannot be reduced except by increased production or diminished consumption, and unless they are reduced we shall be unable to hold our own in either foreign or domestic markets. Unless the workers recognize the necessity for increased production they will seriously endanger our whole industrial structure and create an era of unemployment during which they will be the greatest sufferers.

Close observation of industrial conditions in European countries has shown that in general our workmen, accustomed to the use of labor-saving machinery, are the most capable and economical producers in the world, and therefore entitled to high wages. But even with this advantage there is a point where our production costs pass those of European manufacturers, and that point we have reached in many lines.

* * *

PIONEER WORK BY THE BIG INDUSTRIES

Much credit is due to our larger industrial concerns for what they accomplish through research and experimental work. Many of our big manufacturers appropriate considerable money for developing industrial processes and for improving and originating mechanical and electrical equipment. Progress in engineering, chemistry, and along scientific lines generally, must be preceded by costly experiments and tests which usually require special apparatus. This work cannot be done by small manufacturers for, however enterprising, they lack the necessary resources. It is chiefly in the physical and chemical laboratories of firms doing business on a large scale that this invaluable and often very costly work is carried on. There the idea is tested by men whose aim is practical results achieved by direct, practical means. As in all such work not the least valuable feature of it is the immense amount of data evolved which represent ideas rejected. All achievement involves the arrival at results through learning what not to do.

While the primary object of these laboratory investigations and pioneer work is to benefit a particular business either by the improvement of manufacturing processes or the acquisition of definite, reliable knowledge of unexplored subjects, the fact remains that these discoveries which are continually being made, ultimately prove to be a national asset. Small manufacturers, inventors, and men who are born investigators have, of course, done much toward industrial development, but many important discoveries and improvements may be traced directly to the experimental laboratories of large establishments. In numerous instances, this knowledge would doubtless remain hidden indefinitely were it not for the special efforts and resources of progressive industrial organizations which operate on a scale large enough to warrant the expense of maintaining costly research departments.

* * *

THE TRAINING OF THE SPECIALIST

There are many erroneous ideas in regard to the training required by an expert or specialist in one particular line of machine manufacture or design. It is believed by some that the essential requirements for success in this capacity are a narrow and one-sided training and long experience on the specific line of work involved. As a matter of fact, such a specialist should have an extended knowledge of mechanics in general, because the more he knows about manufacturing problems in varied lines of machine shop practice, the better can he work out any special mechanical problem.

The machine designer, for example, who specializes on one particular kind of machine tool, let it be a planer, a milling machine, or an automatic screw machine, will be all the more successful in his work if he has a general knowledge not only of machine tool design, but also of machine design in general. The more thorough his mechanical knowledge in a wide field, the more efficiently can he apply this knowledge to a specific field and become a specialist of the highest order.

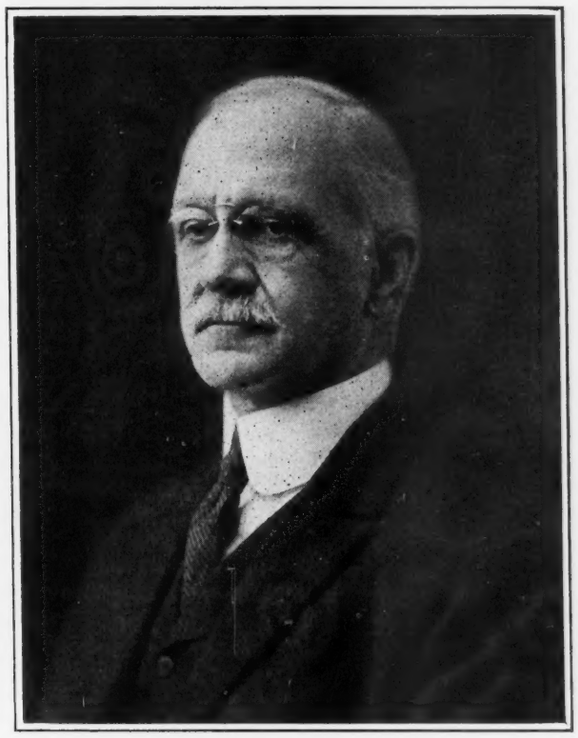
The same principle applies to specialists in shop management and production. The broader their general knowledge, the more valuable and successful they become when they apply this broader knowledge to the one particular line of manufacture in which they are engaged.

Annual Convention of the A. S. M. E.

THE annual convention of the American Society of Mechanical Engineers, held in New York City, December 2 to 5, was the fortieth annual convention of the society. The sessions of the meeting were opened by the presidential address of Professor M. E. Cooley, the president for the past year. In his address Professor Cooley outlined the great scope of the society, its organization, and the functioning of its council and committees. At the same meeting honorary memberships were conferred upon Charles de Freminville, consulting engineer, Creusot Works, France, and Auguste C. E. Rateau, of steam turbine fame, and chairman, board of directors, Rateau, Battu & Smooth Co., France.

Fred J. Miller, the New President of the Society

At the opening meeting announcement was also made of the election of Fred J. Miller as president of the society for the coming year. Mr. Miller was born in Ohio in 1857. He had a common and high school education, supplemented by personal study and special instruction. He served an apprenticeship of four years in the machinist trade, and for a number of years worked in various capacities in machine shops. He became a contributor to mechanical journals and finally a member of the editorial staff of the *American Machinist* on which he served for twenty years, the last ten years of which he was editor-in-chief. During this time he acquired an extensive acquaintance with machinery-building establishments in Europe as well as in America.



Fred J. Miller, Newly Elected President of the A. S. M. E.

After retiring from journalism, Mr. Miller was for nine years general manager of a group of typewriter factories, and was then commissioned Major of Ordnance in the U. S. Army, being stationed during most of his service at the Rock Island Arsenal, where he organized and was at the head of the Civilian Service Division of the Arsenal. Afterward he was attached to the office of the Director of Arsenals in Washington, being assigned to duty at the Bethlehem Steel Works, and was then attached to the office of the Secretary of War. He is now a member of the Technical Advisory Committee of the War Claims Board at Washington.

Mr. Miller became a member of the society in 1890, and has always taken an active interest in its affairs, having served on a number of important committees, and as a member of the council from 1904 to 1907, inclusive. He also served two terms as the society's representative on the board of the United Engineering Societies, where he was chairman of three successive committees entrusted with the work of reorganizing and perfecting the Founder Societies' business affairs and finances. He was a member of the council at the time the *Journal* of the society was started, and has always been consulted on questions relating to its development, having recently devoted considerable time to the study of the society's publishing problems and its office methods and organization.

The professional sessions offered much of interest to the members, no matter in which branch of engineering engaged. The meeting was divided into sections, many of which held simultaneous sessions. At the appraisal and valuations section meeting the following papers were read: "Ice-plant Depreciation", by George E. Wells; "Depreciation of Insulation", by John E. Starr; "Appraisal and Valuation Methods", by David H. Ray; "Fundamental Principles of Rational Valuation", by James Rowland Bibbins; "The Construction Period", by H. C. Anderson; "Price Levels and Value", by Cecil Elmes; and "Original Costs and Normal Values", by R. H. Nexsen. All papers were followed by discussions.

At the gas power section meeting the following papers were read: "The Hvid Engine and its Relation to the Fuel Problem", by E. B. Blakely; "Kerosene as a Fuel for High-speed Engines", by L. F. Seaton; "Combustion of Heavier Fuels in Engines of Constant-volume Type and Super-induction Type Engines", by Leon Cammen; and "Oil Pipe Lines", by S. A. Sulentic.

At the industrial relations section meeting the following papers were read: "The Causes of Industrial Unrest and the Remedy", by Frederick P. Fish; "Wage Payment", by A. L. De Leeuw; "Systems for Mutual Control of Industry", by William L. Leiserson; and "What May We Expect of Profit Sharing in Industry?" by Ralph E. Heilman.

At the machine design section meeting the following papers were read: "Reliability of Materials and Mechanism of Fractures", by Charles de Freminville; "Tests on Dredging Pumps Used in Inner Harbor Navigation Canal, New Orleans", by W. J. White; "A Perfected High-pressure Rotary Compressor", by C. B. Lord; "Turbo-compressor Calculations", by A. H. Blaisdell; and "A New Type of Hydraulic-turbine Runner", by Forrest Nagler. On power machinery the following papers were read: "Emergency Fleet Corporation Water-tube Boilers for Wood Ships", by F. W. Dean and Henry Kreisinger; "Flow of Water Through Condenser Tubes," by William L. DeBaufre and Milton C. Stuart; "Air Pumps for Condensing Equipment", by Frank R. Wheeler; and "Thermal Conductivity of Insulating and Other Materials", by T. S. Taylor.

The sub-committee on textiles arranged for a topical discussion on teaching and training textile mill employes, with contributions from various textile schools and manufacturing plants. A paper was also read on "The Economical Use of Steam in Textile Plants", by George H. Perkins. On the subject of transportation, papers were read on "Scientific Development of the Steam Locomotive", by John E. Muhlfeld, and "Motor-transport Vehicles for the United States Army," by John Younger.

The machine shop practice section contributed the following papers to the meeting: "Common Errors in Designing and Machining Bearings", by C. H. Bierbaum; "Lubrication

of Ball Bearings", by H. R. Trotter; "Thread Forms for Worms and Hobs", by B. F. Waterman; and "Illustrated Talk on Electric Arc Welding", by H. L. Unland. The following papers on general subjects were also presented at the convention: "Octoval Notation and the Measurement of Binary Inch Fractions", by Alfred Watkins; "Modern Electric Furnace Practice as Related to Foundries in Particular", by W. E. Moore; "An Investigation of Strains in the Rolling of Metal", by Alfred Musso; and "Slow-speed and Other Tests of Kingsbury Thrust Bearings", by H. A. S. Howarth.

General Features of the Convention

The main feature of the convention, outside of the professional sessions, was the DeLamater-Ericsson commemoration meeting held on the evening of December 3 to commemorate the eightieth anniversary of the beginning of Captain John Ericsson's work in America and the thirtieth anniversary of the death of Captain Ericsson and of Cornelius H. DeLamater, founder of the DeLamater Iron Works, where Captain Ericsson's most important work was executed. At this meeting an illustrated historical review of the DeLamater Iron Works and of Ericsson's inventions was given by H. F. J. Porter, and addresses were made on Ericsson's contributions to engineering and to civilization by Rear-Admiral Bradley A. Fiske and W. A. F Ekengren, minister from Sweden to the United States. Rear-Admiral Fiske particularly called attention to the world-wide consequences of John Ericsson's inventions and paid a very high tribute to his remarkable engineering genius, the greatness of which the world did not fully appreciate until after his death.

On Thursday evening two lectures were given, one on the future of aviation by Colonel E. A. Deeds, Dayton, Ohio, Chief of Equipment Division of Air Service during the early development of the air program of the war. The Liberty engine was developed under the personal direction of Colonel Deeds. The other paper was on "Present Development of the Military Airplane" by Colonel Thurman H. Bane, Chief of Engineering Division of Air Service and commanding officer of McCook Field. The lecture by Colonel Bane was illustrated by slides and moving pictures released by the War Department for this lecture for the first time.

Abstract of Important Papers

Reprints of the important papers presented before the society may be obtained by non-members for a nominal fee by addressing the society at its headquarters, 29 W. 39th St., New York City. In the following, a brief review is given of some of the papers that are most important to the machine-building field.

Thread Forms for Worms and Hobs

The use of worm-gearing is steadily increasing, and accompanying this increase—perhaps the cause of it—is a corresponding increase in efficiency and durability, which is the result of a better understanding of both the theoretical and mechanical problems. This paper points out some of the problems involved and some of the mechanical difficulties in the use of worm-gearing. Failure to take these problems and difficulties into consideration in the past has often led to the discrediting of this form of drive. Methods for bringing about a uniform and satisfactory practice in worm-gearing are also suggested.

The Lubrication of Ball Bearings

Ball-bearing lubrication is a subject of which little is known, chiefly because there is no accepted method of determining the lubricating value of an oil or grease. As a step toward the development of a satisfactory method, the author has devised an instrument for such a purpose, a brief description of which is given in this paper. The operating characteristics of a ball bearing as related to the problem of lubrication are also discussed, and the specifications for a satisfactory oil are given. The use of grease and graphite as a lubricant is next presented, and the paper concludes with a suggested procedure for the analysis of lime-soap greases.

Common Errors in Designing and Machining Bearings

After presenting ten principles relating to the design, construction, and operation of journal bearings, based on what is now known concerning the laws of lubrication, the author discusses among other things oil-grooves and their proper distribution, the disadvantages of tight-fitting bushings, proper methods of finishing brasses to provide for expansion when running, and proper methods of clamping bearings during tooling. He then takes up the matter of the tools employed in machining bearings and shows by numerous photomicrographs of finished surfaces the importance of using sharp tools with the proper rake in order that the crystalline structure of the surface material of the bearing may not be so crushed and compacted that it will fail to function as a normal bearing alloy.

Slow Speed and Other Tests of Kingsbury Thrust Bearings

This paper presents operating and experimental data which show the wide range of application of the Kingsbury thrust bearing, and the author gives particulars of typical installations which have been in successful operation since 1911. These bearings have been applied to vertical and horizontal hydro-electric units as well as to horizontal steam turbines and centrifugal pumps, and to determine some of the service conditions a series of slow-speed tests was recently made on a bearing having a total area of 76 square inches on its four shoes and a load of 10,000 pounds. Details of these tests are given and the results obtained indicate that the lower the speed at which the bearing is run continuously, the better the conditions of the bearing surfaces. Speeds as low as 0.38 revolution per minute have thus far been employed, using, however, only a light oil.

An Investigation of Strains in the Rolling of Metal

In every manufacturing process, while raw stock is being transformed into a finished article, a certain amount of material is incidentally wasted, and the minimizing of such waste constitutes one of the most important problems to be solved by the operating engineer. Rolling-mill operations are no exception to the general rule, and the problem may be specifically set forth as follows: What is the most convenient length and width of the piece of metal to be rolled, in order to produce a finished article of certain definite dimensions, so that the waste of material may be reduced to a minimum? A complete answer to this complex question depends on data of various natures resulting from actual investigation. We may, however, group these data into two classes: To the first class belong all data of a general character obtained through mechanical investigation; and to the second, data obtained through investigation of the special condition under which the manufacturing takes place. The scope of this paper is the exposition of some fundamental principles leading to data of the first class.

Modern Electric Furnace Practice as Related to Foundries in Particular

Since 1913 the number of electric furnaces employed in the steel industry in the United States and Canada has risen from 19 to 335, practically all of which are of the arc type. After first giving particulars regarding the operation of acid and basic furnaces, the author enumerates the superior properties which have created the present demand for electric steel. He then points out the advantages of the electric furnace over the open-hearth furnaces in steel melting and states the features of the various classes of arc furnaces which have made that type practically supreme in its field. Following this the crucible and converter processes are briefly described and it is shown how the acid type of furnace is the best for foundry work. Comparative operating costs of producing liquid steel by the converter and electric-furnace processes are then given, which bring out the marked economy of the latter. The paper concludes with notes on the employment of the electric furnace in malleable-iron foundries and on the selection of the most suitable types.

French Industrial Conditions

By A. L. VALENTINE, Works Manager, Societe des Usines Curial, Paris

In this article, the author gives an interesting inside view of French industrial conditions. Mr. Valentine was until recently connected with a well-known maker of small tools in the United States, and came to France last summer as works manager of Societe des Usines Curial in Paris, which firm is now also building a large plant outside of Paris for the manufacture of small tools on a large scale. His observations are the more interesting as he sees the French conditions from an American viewpoint, at the same time being in a position to come closely in contact with the details of the present situation in France.

INDUSTRIAL conditions in France are upset, there is no doubt about that; but it may be stated that in spite of all that the newspapers have printed, there are fewer strikes there than in the United States, and when one considers how little the French manufacturer need do to satisfy the workers, it is not likely that serious labor troubles will be encountered. Generally speaking, all that the French workers ask is what they are entitled to as men and women, and what every employer in the United States has always provided as a matter of course. It may be expected, therefore, that France will shortly get back to a stable basis; and if French workmen in general are as capable and adaptable as those employed in the factory in charge of the writer, it will require but a short period of training to bring them up to the standard of the workers in the mechanical industries in the United States. French workmen appear to be fully as capable as those in the United States, and the only thing lacking to bring them up to their full efficiency is sufficient incentive to exert themselves to do more and better work, and to run the full number of machines to which each man can attend.

Lack of Modern Machinery

One of the most serious drawbacks to the rapid growth of the French industries is the lack of modern machine tools and the great difficulty of obtaining them from the United States. If it were not for the sales of machinery from war plants, I do not know what we would do for machine tools, as the sales rooms of the agents of American machine tools are practically empty. In spite of the offerings of machine tools from government factories and the American government machine tools, the facts are that the French machine tool market is bare of supplies, and that American and British machine tools cannot be obtained in sufficient quantities. Some French manufacturers, unable to obtain American machine tools, and seeing the chance for a good domestic trade, are planning to begin the manufacture of different lines, and as an example I may mention that even in our factory we are seriously thinking of manufacturing certain machinery of smaller sizes in quantity, in spite of the fact that we are not now at all in that line of business.

German Machine Tool Competition

In the reports published by Mr. Luchars, it was pointed out that the French are likely to buy machine tools from Germany, both because of the lower price and the more rapid deliveries. I can confirm this statement, for in spite of the hatred that exists between the two nations, German machinery cannot be kept out of France; because, in order to put more speed into French industry, machine tools of some make and kind must be obtained. The more rapid deliveries possible from Germany, because of its proximity to France also influences purchases.

Having visited a great number of French machine shops, and having had conferences both with their business and engineering heads, I firmly maintain that if American machine tool manufacturers could keep a plentiful supply of machines in stock in France, or ready for quick delivery, American machine tools would be used almost exclusively, because their superiority is recognized by most French engineers. They know that the German machine tools are not as good; and furthermore, they do not like to use German machinery unless absolutely forced to do so. Hence, all statements to the contrary notwithstanding, American machine tools can be sold in France, provided the exchange again recedes to eight francs to the dollar. While German machine tools are often the same in design as American, many being copies of American types, everybody recognizes that they are of decidedly inferior workmanship.

French competition need not be feared unless a machine tool industry is developed in France by the necessity of obtaining machine tools from a domestic source, foreign tools not being obtainable. Generally speaking, French manufacturers are not inclined to go into new lines of manufacture, and there will be very little competition from French makers in the machine tool field except in case of necessity; but the French certainly have remarkable push and vigor when faced by necessity.

Equipment of French Factories

A short while ago I visited the big steel mill of Jacob Holzer & Co., at St. Etienne, not far from Lyons. These works, I was told, employed about 6000 men during the war (mainly making shells), but are now employing only about 2500 men. In this factory I found nothing lacking in speed, efficiency, and manufacturing methods, even when compared with similar shops in the United States. The laboratory in these works would compare favorably with anything of the kind I know of in America. It was immense in size and equipped with instruments and machinery of the highest class. Every detail in the chemical department, the physical testing department and the photomicrographic department, was worked out minutely. As an interesting example of efficiency in heat-treatment, it may be mentioned that several solid high-speed steel cutters, 12 inches in diameter and 7 inches long, were hardened. Of course, solid cutters of this size would not be considered good practice, but it certainly is a remarkable hardening feat to heat-treat such cutters without loss.

Generally speaking, the steel made by the French mills is superior to that obtainable in the United States as regards uniformity and quality, but sizes are not as accurate and the bars are not as straight. Steel, however, is very scarce, nearly every order for the making of small tools having to be made up special, which causes long delays; in fact, deliveries of finished tools could probably be made from the United States about as quickly as they could be delivered from a French factory because of the delay in obtaining steel. The reason, of course, is that the steel companies have no inducement to carry in stock a line of sizes of high-speed or carbon steel bars such as are required for making small tools, because, as yet, there is not in the whole of France a small tool factory of any great importance, although the firm of Jacob Holzer makes twist drills on a considerable scale. This firm is quite up-to-date in its small tool manufacture, especially in the hardening department, from which even American manufacturers could learn a great deal.

Another large manufacturing plant in France that would interest American visitors, is the Etablissement Emil

Mayen, Paris. This factory, I was told, covers about 265,000 square feet of floor space, and is as up-to-date as any factory I have ever seen, probably because it was constructed by American engineers and built under American supervision during the war. This plant is said to have turned out thirty-five Hispano-Suiza airplane engines daily during the war. Most of the machine tools are of American make, and all of the machinery is kept in excellent condition. This establishment is now selling out its machine equipment, consisting very largely of automatic machines, nearly new and in excellent condition; and were it not for opportunities of this kind, the equipping of new manufacturing industries would be delayed to a great extent.

Working Conditions in France

Working conditions in France are so inferior to those provided for American workmen that they are hardly believable to a man who has been trained in the United States. The low social standing of the French factory worker as compared with his superiors, and the undesirable living conditions, are a handicap to the French industry, because men cannot attain their highest efficiency when living as the French factory workers have to live. No workers in the United States in the small tool or machine tool line would be satisfied to live in such quarters or in such surroundings as do the French workmen of the same ability and general capacity. Nevertheless, they seem happy under these conditions and more satisfied than the workmen in the same line in the United States. This being the case, very little improvement is made in their conditions either by the owners of factories or by the municipal authorities. So-called welfare work is practically unknown. If rest rooms, dining rooms, club rooms, bowling alleys, etc, were suddenly provided in French factories, I believe that the French workers would think that the end of the world had arrived and that a miracle was happening. Conditions will doubtless improve, and I am firmly convinced that as they do, the efficiency of the French worker will also rise, until he will become the equal, if not the superior, in working capacity of men of any other nationality.

* * *

FIXTURE FOR MILLING CAM GROOVES

Comparatively small-sized milling machines may often be advantageously employed for the performance of manufacturing operations on what is strictly production work. A case of this kind is shown in Fig. 1 which illustrates a No. 2 plain cone-driven miller built by the Cincinnati Milling Machine Co. of Cincinnati, Ohio, equipped with a special high-speed vertical attachment and work-holding fixture to provide for milling cam grooves in pieces of work of the form which is shown standing on end at the front of the machine.

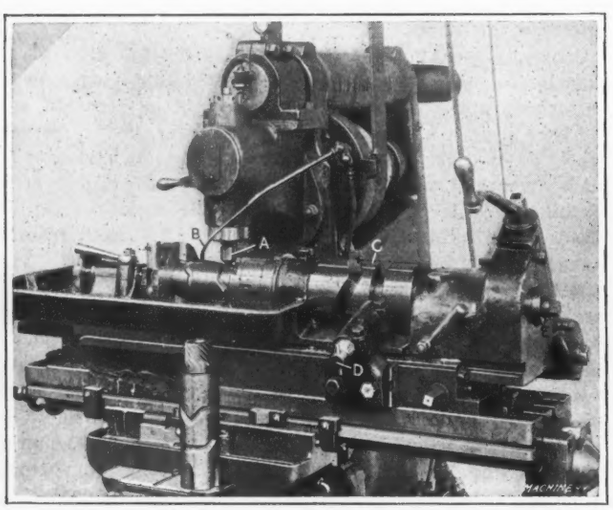


Fig. 1. No. 2 Plain Knee Type Milling Machine equipped with Fixture for milling Cam Grooves

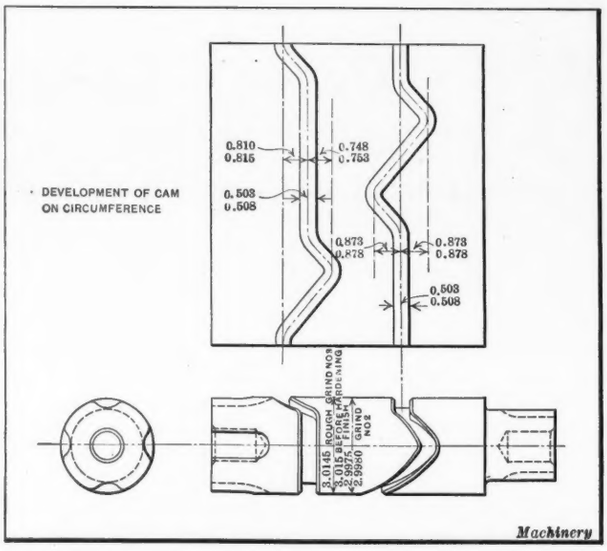


Fig. 2. Layout of the Grooves to be milled in the Cam

Reference to this illustration will enable an experienced mechanic to follow the method of handling this job without requiring more than a very brief description. It will, of course, be apparent that the milling is done by an end-mill carried in chuck *A*, and a tube *B* provides for delivering lubricant to the cutter and work. The milling cutter is of proper width for the cam groove, but provision must be made for guiding the work in order to have the cam groove of the desired form. This result is obtained by means of a master cam *C* in which there runs a roller carried at the inner end of stud *D*. The work and master cam *C* are both mounted on a horizontal shaft, the end of which is shown at *E*. This shaft is rotated by gears contained in a case clearly shown in the illustration, and as master cam *C* revolves, a reciprocating longitudinal movement is imparted to the whole fixture which is carried on a slide, while stud *D* is held in a fixed bracket. This movement of the fixture is governed by the groove in cam *C* in which the roller is held, and thus determines the form of the cam groove milled in the work.

The material of which this cam is made is a grade of steel known as hub stock. There are two cam grooves to be milled, which are ½ inch in width by 5/16 inch deep, and they extend around the entire circumference of the cam which is 3 inches in diameter. After the milling of one cam groove has been completed, the fixture is shifted over to bring the roller into the other groove in cam *C*. The second cam groove can then be milled in the work. The maximum throw of the cam grooves is ⅞ and 13/16 inch, respectively. Each groove is finished at a single revolution of the work, and the cutter used for this purpose is a single-bladed end-mill made of high-speed steel. It is driven at 1410 revolutions per minute, which corresponds to a cutting speed of 175 feet per minute. The work is fed to the cutters at a rate of 5.33 inches per minute, and the total time required to complete the operation is 34 minutes from floor to floor.

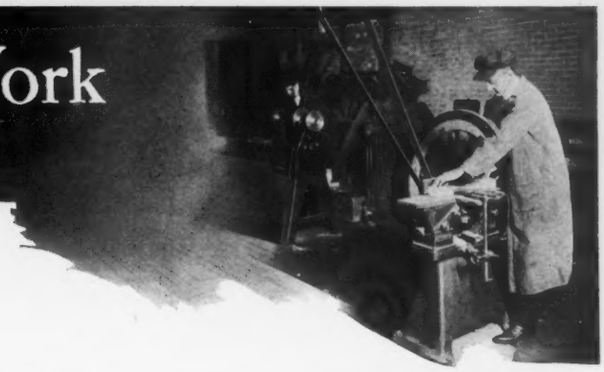
* * *

CENTRIFUGAL STEEL CASTINGS

The Bureau of Standards has made public the results of some investigations on steel castings made by the centrifugal method, which produces an ingot of hollow cylindrical form. When this method is used, the density across the section of the casting is practically constant, and blow-holes appear only in a thin section next to the inside surface. Tensile and shock tests show greater strength and elasticity, but less ductility, in the tangential than in the longitudinal direction. Very slight internal stresses are developed by this method of casting, and by proper heat-treatment it is possible to produce steel castings which compare favorably with forged materials of the same composition.

Finishing Pattern Work

By Joseph A. Shelly



THE finishing of patterns includes the application of fillets, the rounding of corners, and the final sandpapering and varnishing. The putting in of rapping plates and lifting and drawing devices, as well as the fastening of pattern letters and the final checking for errors before sending to the foundry, is also a part of this work. The final appearance of any pattern will depend largely upon the neatness with which the finishing is done. It will make but little difference how well made or assembled the different parts of a pattern may be, a poor looking pattern will result if the corners are not well rounded and if the fillets are poorly put in. Any parts that may be difficult to sandpaper after the assembly should be attended to beforehand. Core-boxes are often easier to sandpaper before they are put together or the ends or sides are put in place. All glue should be cleaned off before varnishing. The easiest way to clean the glue is while it is soft and can be taken off with a sponge or piece of waste saturated with hot water. If this has not been attended to and the glue has dried, it will have to be taken off with a scraper. Nails should be used in all glued joints and, whenever possible, in fillets. The pins in parted work should be sandpapered until the pieces part freely and skewers should be filed or scraped until they withdraw easily. Loose pieces should be carefully examined to make sure that they will draw into the pattern cavity in the mold.

Fillets

Fillets are concave connecting or corner pieces used at the intersection of surfaces. They are either "stuck" or "planted." A stuck fillet is one that is worked from the solid, and a planted fillet is one made separately and applied. Planted fillets, which are the ones commonly used, are made of wood, leather, beeswax, putty, and other plastic materials. Metal fillets have also been used to some extent, but are not very popular, as they are hard to fasten and soon work loose.

Wood fillets are used on straight work or for corners of large radii. They may be purchased, but are usually made by the patternmaker. Wood fillets are planed with a round plane (*A*, Fig. 1) in lengths to suit. These planes are made in different widths varying from ¼ inch to 2 inches. They usually come in pairs, each round or convex plane having a corresponding hollow or concave plane. The round plane, however, is the only one used by the patternmaker. Two edges of the stock are planed to slightly more than 90 degrees as at *B*, so that the edges of the fillet will lie flat when fastened in the corner. The stock is first reduced to a triangular section on the circular saw, and is then placed on the fillet board for planing with the round plane. The fillet board *C* is a board of suitable length provided with grooves of different sizes for holding the fillet while it is being planed. A projecting screw-head at the end of each groove acts as a stop for the fillet.

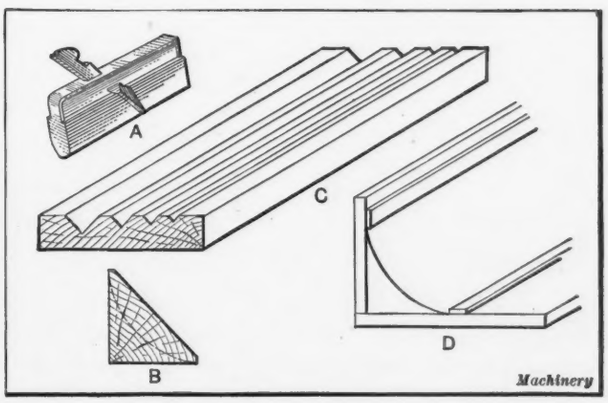


Fig. 1. (A) Round Plane for forming Fillets. (B) Section of Fillet Stock. (C) Board used for holding Fillet Stock while planing. (D) Edges of Large Fillet held down by Thin Strips while Glue is setting

Wood fillets should always be glued in place and securely nailed. A round-ended stick is handy to rub the edges flat. The applying of glue to one side of the fillet will cause the edges to curl; to counteract this, the face or concave side should be wet with water before the glue is put on. The shim or feather-edges on large fillets should be held down by tacking thin strips over them, as at *D*, Fig. 1. These are removed after the glue has set.

Leather fillets are triangular strips of leather cut in four-foot lengths. Samples are shown at *A*, Fig. 2. They come in different sizes and are in general use for fillets of one inch radius or less. The extreme pliability of leather fillets makes them easy to apply to straight or curved work or to acute or obtuse corners, as illustrated at *B*. This pliability may be increased by moistening with water. Leather fillets may be fastened with glue or thick shellac. They are rubbed in place with a spherical ended tool *D*. If glue is used, the rubbing must be done very rapidly, before it has a chance to set. Shellac is perhaps best for this purpose, as it permits more time for rubbing. The back or angled side of the fillet should be coated as well as the corner to which it is to be applied; if the shellac is thin, several coats should be put on and allowed to become sticky before rubbing into place with the spherical-ended tool.

Beeswax fillets are used on small work and applied after the first coat of varnish. The "beeswax gun" is a device for preparing wax for use as fillets. A simple form consists of a tube closed at one end, as shown at *C*, Fig. 2. A wooden piston or plunger is fitted to the open end. The tube is partly filled with beeswax and the plunger inserted; the wax is forced through the opening in the side of the tube by placing the gun in a vise and forcing the plunger against the wax. If the tube is held in hot water before squeezing, the wax will come out more easily. It will be in the form of a long string and its cross-section will be similar to the opening in the side of the tube, which is sometimes round and sometimes triangular. A hole 3/32 inch in diameter will make a beeswax string suitable for a ¼-inch fillet. Beeswax fillets are rubbed into the corners with spherical-ended fillet tools. In cold weather, these should be warmed by dipping in hot water; a little oil applied to the end of the tool will keep it from sticking.

Putty fillets are used for cheap work or for a temporary job. They are sometimes made by mixing whiting and varnish, but are not very satisfactory for standard work. Metal fillets are made of lead or white metal. They are hard to fasten securely and do not bend to curves easily.

Tools for Rounding Corners

Projecting edges on patterns, except the edges of parts that are to be machined

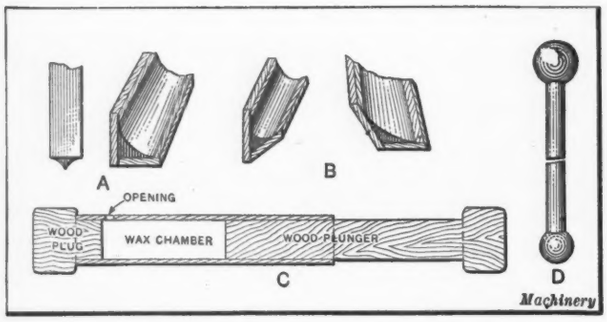


Fig. 2. (A and B) Leather Fillets. (C) Tube or "Gun" for forming Beeswax Fillets. (D) Tool for applying Leather Fillets

or to be fitted to some other piece, are finished by rounding to a quarter circle. The smaller corners up to ¼ inch may be worked off accurately enough to the eye, but even these will have to be gaged. The ordinary marking gage will not do for this purpose, as the spur makes a disfiguring line and the gage will not run freely around convex and concave curves or sharp corners. The gage shown in Fig. 3 is well adapted to this purpose; it consists of two pieces of hard wood *a* and *b*. Piece *a* is slotted and the piece *b* has a projection that fits the slot. A round-head wood-screw permits it to be clamped at any point in its travel. The marking point or spur is a pencil point.

The tools used for rounding corners include the large and small block planes, the long- and short-handled spoke-shaves *A* and *B*, Fig. 4 (for both wood and metal), and a sharp knife. The spoke-shaves should be in pairs with both flat and convex rounded faces. Patternmakers usually cut the long handles off short, as they are often in the way. It is a good plan, however, to be provided with both kinds. The corner-rounding tool shown at *C* makes a complete corner at one cut; it works well with the grain on straight-grained wood, but not so well across the grain. These tools are made in a number of sizes.

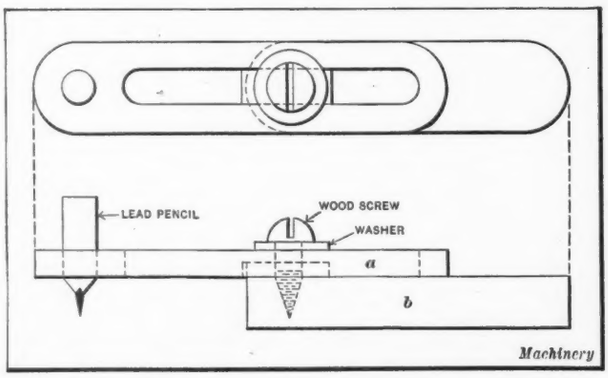


Fig. 3. Type of Gage used for marking Corners preparatory to rounding

Templets should be used for trying corners having a radius of ⅜ inch or more, while working them to shape with the tools. Cardboard templets (*C*, Fig. 5) will do very well, but for corners of 1 inch radius or larger a templet made of ¼-inch stock will be better, as it may be chalked and rubbed to see where the stock should be removed. A good form of wooden templet is shown at *D*.

In rounding corners of large radius, they should first be gaged and then chamfered tangent to the radius at an angle of 45 degrees. To do this accurately, the corner radius should be laid out on a piece of board as at *A*, Fig. 5, a 45-degree chamfer marked out, and a line gaged from the edge each way to guide the workman in removing the corner, as at *B*.

Sandpapering

Sandpaper is a heavy paper coated with an abrasive material of different degrees of coarseness. These are designated by numbers starting with 000, which is the finest grade, and ending with 3, which is the coarsest. The numbers used in most pattern work are, 0, ½, 1, 1½, and 2. Sandpapering blocks are wooden blocks around which the sandpaper is tightly wrapped when operating on large surfaces. For plane surfaces and convex curves, a straight-faced block is used. Blocks of cork are sometimes used or wooden blocks faced with cork; they are more elastic than wood and conform slightly to irregularities in the wood. Blocks for concave surfaces should be shaped to conform to the surface, while for straight round core-boxes, cylinders should be turned and kept for this purpose. These cylinders should be of such a diameter that when the sandpaper is tightly wound around them, they will just equal the diameter of the box.

Pattern sandpapering is done by moving the sandpaper back and forth across the grain of the wood or in the opposite direction to which the tool traveled in working the pieces to shape. Coarse sandpaper should be used first and fine sandpaper for the finishing touches. Care should be taken not to destroy plane surfaces and corners that are meant to be sharp. Much of the rubbing on rounded corners will be done with the sandpaper held in the hand. The paper should be torn in square or rectangular pieces and folded twice, as in Fig. 6. This will give three working faces and is the most economical way to use it.

Pattern Varnish or Shellac

Varnish used as a protective covering for patterns has for a base what is known as yellow or orange shellac. Shellac comes in thin brown, flaking, irregularly shaped pieces. It is mixed or cut by placing a quantity of it in a glass or eathenware jar and adding enough alcohol to cover it. The alcohol may be grain, denatured, or wood; any of these will do, but grain alcohol is the best. Wood and denatured alcohol are generally used on account of their lower cost. Black shellac is made by adding to orange shellac a good quality of lampblack that is free from grit. A good grade of finely dry-ground vermillion will make an excellent red shellac.

Pots for holding clear or yellow shellac should be of glass or earthenware, as the chemical action set up by the use of a metal pot will darken the shellac; a metal pot, however, may be safely used for black or red shellac. Shellac pots should have tightly fitted covers to prevent excessive loss through evaporation. Shellac that has become discolored may be cleared or cleaned by adding a small quantity of powdered oxalic acid, but care should be taken not to get this mixture into cuts or wounds, as oxalic acid is poisonous.

Shellac is best applied with a flat chisel-shaped brush made of badger or camel's hair. These brushes come in a number of widths, but for pattern work the 1-, 1½-, and 2-inch widths will be found most convenient. A leather- or rubber-bound brush should be used for clear shellac, as a metal binding will affect the shellac in the same manner as a

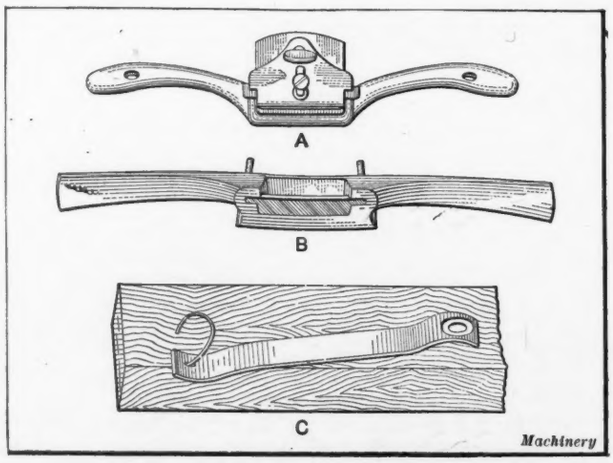


Fig. 4. (A and B) Spoke-shaves for rounding Corners. (C) Corner-rounding Tool

metal pot. To keep the bristles straight, the brush should hang in the pot and not stand on the bottom.

Shellac varnish dries quickly, and if of good quality is not easily affected by heat or moisture; it has the added advantage of being easy to cut through if alterations are called for after the pattern is finished. The first coat should be evenly applied, and the varnish should not be too thin, as the moisture has a tendency to raise the grain of the wood, and if applied too thin will roughen the surface so that it may never be smoothed. The first coat should be given ample time to dry before the second is applied. There is no rule as to the amount of time to allow, but the more the better. Before applying the second coat, the surface of the pattern should be rubbed smooth with a piece of fine sandpaper held in the hand, and this should be done between each successive coat. Never use a block for sandpapering a varnished surface. The number of coats to apply will be governed by local practice, but for good work at least three coats should be given.

Varnishing Core-prints and Outlines

Core-prints and places where cores will cut through to the exterior of the casting, as well as core outlines or sections on the joints of parted patterns, are indicated by a different color varnish from that used on the body of the pattern. If yellow is the color of the pattern, the core-prints and designated portions will be black; if black is the pattern color, the prints will be either yellow or red. It is the practice in some shops to use a given color on patterns as an indication of the metal it is to be cast in. For example, all patterns to be cast in iron would be black; red would indicate steel; and yellow would mean brass or composition.

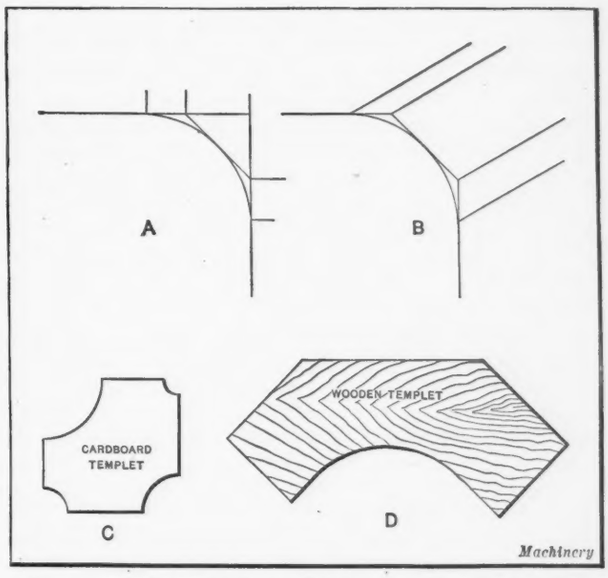


Fig. 5. (A and B) Method of chamfering Large Corners preparatory to rounding. (C and D) Corner Templets

Rapping and Lifting Plates

Rapping plates are pieces of metal let in flush with the joint or cope side of the pattern and fastened with screws. They come in different shapes and sizes (a few samples are shown at *A*, Fig. 7), and are provided with a central hole that is tapped to receive the threaded end of the lifting iron *B*. In addition to the tapped hole, there are one or more plain holes for the reception of the rapping bar. Countersunk holes are provided for the fastening screws.

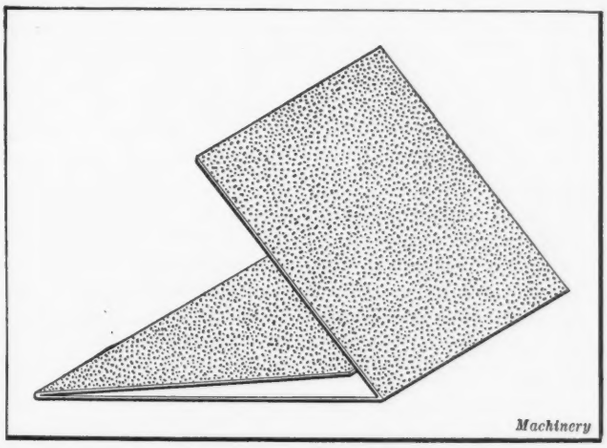


Fig. 6. Method of folding Sandpaper

The recesses for square and rectangular plates as well as for those with scalloped edges, are laid out by placing the plate on the pattern and tracing the outline with a scriber. The scalloped edge plates are designed to be let in flush by boring a series of holes to a depth equal to the thickness of the plate. A Forstner bit and a bit stop should be used for this purpose.

The number of rapping plates and their location will depend entirely upon the shape and size of the pattern. If the pattern is small or medium sized and plain in shape, one plate will be enough. It should be located at a point where the pattern will be in balance when it is drawn with the lifting iron. If the pattern is large or cannot be easily balanced or rapped with one plate, it will be necessary to install two or more plates to carry the weight and balance the lift. Lifting straps *D*, Fig. 7, are applied to deep patterns. These are used solely for lifting purposes, and are usually made of ⅛- or 3/16-inch bar iron of suitable width and provided with countersunk screw-holes.

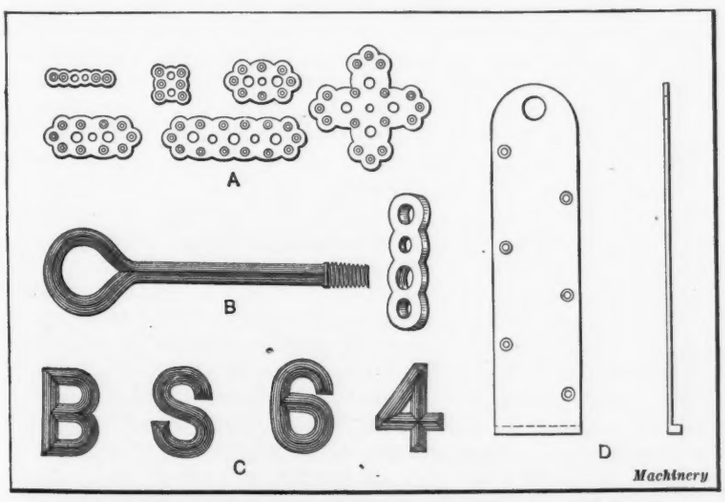


Fig. 7. (A) Rapping and Lifting Plates. (B) Lifting Iron. (C) Pattern Letters and Figures. (D) Lifting Strap

Finishing Metal Patterns

The surfaces of metal patterns should be filed smooth and all holes should be filled with solder or lead. There are several methods of finishing surfaces, the simplest of which is called the rusting process. All oil and grease must be removed by a steam bath or by scrubbing with hot soda water; this treatment is followed by several successive applications of a solution of water and sal-ammoniac, in order to get a well rusted surface which is rubbed to a smooth finish with emery cloth. The final finish is given by heating the casting and rubbing beeswax on the surface while it is warm. This is to prevent the damp sand from sticking to the pattern or causing it to rust.

Pattern Letters

Pattern letters are used for reproducing firm names, identification letters, or figures on castings. Samples are shown at *C*, Fig. 7. They are made of either brass or a soft alloy of tin and lead, and they may be procured in three styles known as Roman, sharp-faced Gothic, and flat-faced

Gothic. The letters are ⅛ to 4 inches high. The brass letters are used on metal patterns, and the soft metal ones on wood.

Brass pattern letters are attached to metal patterns by sweating. The surface to be covered by the letters, and the backs of the letters themselves, are tinned or given a thin coat of solder. This is done by heating the surfaces enough to melt the solder. A flux such as sal-ammoniac should be applied before the solder. The tinned surfaces are then reheated and the letters put in position. Soft metal letters are fastened to wood patterns by means of shellac, or shellac and small brads. Before an attempt is made to apply the letters to a pattern, their position must be decided upon and lines drawn as a guide for setting the letters. The letters first should be arranged dry for position and spacing, and the position of the first and the last letter in each line marked. The letters are then placed face downward on a board and shellacked, as is also the surface to which the letters are to be applied. When the shellac has become quite sticky, the letters should be reapplied and adjusted. A knife with a sharp pointed blade is used for this purpose.

Checking is the final inspection to which all patterns should be subjected as a safeguard against possible errors before they are sent to the foundry. There are no fixed rules

FACTORS FOR OBTAINING WEIGHT OF CASTING FROM PATTERN WEIGHT

Pattern Material	Factors			Pattern Material	Factors		
	Cast Iron	Composition	Aluminum		Cast Iron	Composition	Aluminum
White Pine	13.00	15.13	4.51	Cast Iron...	1.00	1.16	0.35
Mahogany ..	10.28	11.97	3.71	Aluminum .	2.88	3.35	1.00
Cherry	10.70	12.44	3.72	Composition	0.86	1.00	0.30

Machinery

for checking work, but it is a good plan to compare the pattern with the drawing, view for view, before making any measurements. Be certain that all the pieces are on the pattern and in the proper relation to each other. The pattern should then be measured by referring first to the dimensions on one view of the drawing only. To facilitate checking, all center lines should be cut rather deeply with a sharp knife point, so that they will not be obliterated in finishing the pattern. Over-all lengths and widths, distances between centers of hubs and bosses, sizes of facing pieces, diameters of flanges, and all important dimensions on each view should be measured first. Thicknesses of webs and ribs or other parts of minor importance should be left to the last. After checking the figures, the try-square and protractor are used to test those surfaces that lie at an angle to one another.

Core-boxes should be carefully checked to see that they will leave the proper thicknesses of metal around the core and that the cores will fit the prints. Allowance must be made for a natural increase in the size of large cores due to swelling and settling, and care must be taken to see that the core-boxes are somewhat smaller than the prints. The natural tendency of plates is to increase in thickness in the casting, so that if a plate of a required thickness is wanted, the pattern will have to be made somewhat thinner. Deep beds also will increase in depth.

Approximate weights of castings may be obtained by weighing the pattern and multiplying the weight by a factor given in the accompanying table. If a white pine pattern weighs 6½ pounds, its approximate weight when cast in iron will be 6½ times the factor found in the table under cast iron and opposite white pine or $6\frac{1}{2} \times 13 = 84$ pounds. If there should be a cored hole through the casting, the weight of the cored part can be found by filling the core-box or boxes with dry sand and weighing the sand, which should then be multiplied by one of the following factors: For cast iron, 4; for composition, 4.65; for aluminum, 1.4. This product should be subtracted from the first weight obtained to get the net result. As an example, if the weight of the sand in the core-box is 8¼ pounds, then the net weight of the casting will equal approximately $84 - (8\frac{1}{4} \times 4) = 51$ pounds.

SCIENTIFIC DEVELOPMENT OF THE STEAM LOCOMOTIVE

In a paper presented before the annual meeting of the American Society of Mechanical Engineers, John E. Muhlfeld discussed the general lines along which improvements may still be made in steam locomotives. It was pointed out in the paper that despite the fact that marked progress has been made in the development of the steam locomotive, there still remains considerable opportunity for further progress. Briefly outlined, the paper dealt with factors involved in the determination of tractive power of locomotives and discussed such items as boiler feed-water, types of fuel, combustion, steam pressure, superheating, and steam generation. Acceleration and deceleration of locomotives were also considered, and in conclusion a discussion was made of the methods of saving fuel and labor in order to obtain a high standard of operation and economy.

An interesting part of the paper made reference to the power used for accessories. The steam locomotive must not only produce superheated steam for the development of draw-bar pull, but also supply saturated steam to various accessories of its own and for train operation. For example, a modern passenger locomotive is required to supply power to operate locomotive and train air brakes and signals as well as train lighting, heating and ventilating equipment, and hot- and cold-water systems, and in addition it must supply steam or compressed air for the operation of a multitude of devices. As much as 20 per cent of the fuel as fired for an average divisional run may be used for these accessories.

Not only has the use of compressed air been found to be most expensive for the working of these accessories, but the reserve supply for train braking has been frequently drawn upon for their operation. As power reverse gears, fire doors, water scoops, coal pushers, ashpan doors and like devices can be equipped for steam operation, such substitution offers possibilities for less drain on the boiler and much-needed economy in the cost for this auxiliary power production. Moreover, as all of this power for accessories is produced by saturated steam, some means for substituting the use of superheated steam for those purposes where it is more suitable and economical should be given due consideration.

It was also pointed out that the cost for locomotive fuel and repairs averages over seventy-five cents per mile run, or five times what it was ten years ago. This being the case, the question of materials, construction, and equipment of locomotives must be placed on a strictly economical engineering rather than on a purchasing price basis, because first cost is now becoming proportionately less important as compared with the efficiency and cost of maintenance.

The question of lubrication was also dealt with. It was pointed out that it is false economy to restrict the quantity of lubrication used or to employ inferior lubricants to the extent that results in excessive friction, wear and tear, and any saving thus effected is many times over expended in delays, repairs, and fuel. At the same time probably no locomotive supplies are handled more wastefully or ignorantly than oil and grease, due to the lubricant not being applied or used in the proper manner.

Difficulty of access to the various bearings to be lubricated and the necessity for frequent hand oiling have no doubt contributed to lubrication waste and trouble, but during the last fifteen years the substitution of grease for oil on many bearings, the use of larger driving wheels and lower piston speeds, and greater accessibility to certain parts, which obtains from the use of outside instead of inside valve gears and journals, have brought about a substantial improvement.

One of the greatest and simplest improvements to be made in the steam locomotive can be effected by an increase in the boiler pressure in combination with greater quantity and better quality of saturated-steam production, higher and more uniform superheat, and compounding.

Clutch Design

An Analysis of the Forces which must be Considered in Designing Multiple Disk, Cone, and Toothed Clutches, and an Application of the Inclined Plane Principle to the Tooth Form of a Solenoid-operated Clutch

By H. M. BRAYTON

A CLUTCH may be defined as a device used to connect or disconnect two revolvable parts so that motion and power may be transmitted from the driving to the driven member at the will of the operator. Strictly speaking, gears might be classified as clutches under this definition, as they are often used for this purpose but they are not generally thought of or classed as clutches for the reason that it is seldom possible to bring them into mesh while the machine is in operation unless the load is light or they are both rotating at about the same speed. If a stationary gear is forced into mesh with one which is revolving, the shock is often sufficiently great to cause breakage of the teeth of the gear.

Herein lies the necessity for clutches of other types, that is, for meshing a revolving shaft with one at rest or one which is turning at a different speed. A clutch quite commonly used under such conditions is the multiple-disk type. This clutch transmits motion and power entirely by friction developed by forcing several disks or plates together. Half of the disks or plates are held on one shaft, while the other half are held in a member secured to the other shaft. The plates are sometimes made of sheet steel, usually of a soft grade. In this case the clutch would be made to run in oil, as dry steel plates are likely to start the mechanism too suddenly. The oil reduces the coefficient of friction, thus causing the clutch to slip somewhat before it finally picks up the full load.

Steel plates lined with various friction materials are also used, and such plates may or may not run in oil. When used dry, they form what is known as the dry-plate clutch. Asbestos, interwoven with fine copper wire, is generally used for lining dry-plate clutches, and good results are obtained with this type, which is often used in automobiles.

Theory of Disk Clutches

In order to create friction between two surfaces, it is necessary to force them together, and the amount of friction thus produced is proportional to the normal force, or the force that holds them together. In other words, if it is desired to transmit power from one shaft to another by means of a disk clutch, it is necessary to force the clutch plates together. One or more springs are usually employed for this purpose, being arranged so as to force a sliding collar along the shaft, one half of the plates, of course, being held on the collar. The question now arises as to how strong the spring must be in order to drive the machine. The clutch must be capable of transmitting all the power developed by the prime mover and have an additional amount of power sufficient to insure proper operation at all times. The strength of the spring needed will depend on the following variables: Coefficient of friction between the plates, diameter of clutch plates, speed of shaft, and power to be transmitted. Practically the entire surface of each plate is in contact, but as the total friction developed is not dependent on the area in contact, it is evident that it is also not dependent on the number of plates. All of the variables referred to, however, must be known in any particular case before the size of the spring can be determined. The only factor which must be assumed is the coefficient of friction, and this may be closely estimated.

After the above factors have been determined, it is possible to find the driving force on the plates in the plane of their contact surfaces. Theoretically, there are an infinite number of forces acting tangentially, so to speak, in the surface of contact. These minute forces exist on all of the plates, and it would be impossible to determine their individual magnitude. However, it is not the value of each individual force that is required but the aggregate or total sum of these forces acting on the contact surface of one plate. These forces may properly be considered as being concentrated in one large force acting tangentially to an imaginary circle on the surface of a plate. This force will act at the radius of gyration of the surface, which in the case of a thin disk having a central hole is as follows:

$$g = 0.7071 \sqrt{R^2 + r^2}$$

in which g = radius of gyration;
R = outside radius; and
r = radius of the hole.

This force P may be determined by applying the well-known horsepower formula as follows:

$$\text{H. P.} = \frac{\pi DNP}{12 \times 33{,}000} = 0.00000794DNP \qquad (1)$$

in which H. P. = horsepower to be transmitted;
D = twice the radius of gyration, expressed in inches;
N = speed of shaft in revolutions per minute.

As the value of the force P is desired, this formula would be rewritten as follows:

$$P = \frac{\text{H. P.}}{0.00000794DN} \qquad (2)$$

This equation will give the force in pounds which represents the total friction force in the plane of the plates, but this force acts in a plane at right angles to the line of force of the spring; therefore it is necessary to take into consideration the coefficient of friction in order to determine the latter force. It is a fundamental principle of mechanics that the force required to move a body along a frictional surface is equal to the product of the normal force (that is, the force holding the two surfaces together), and the coefficient of friction between the two surfaces. Expressing this in the form of an equation in which F equals the friction coefficient and P_1 the normal force,

$$P = FP_1 \qquad (3)$$

or

$$P_1 = \frac{P}{F} \qquad (4)$$

Now, as P_1 is the value required, the value of P as given in Equation (3) is substituted in Formula (2). This gives a formula from which we can calculate the force P_1 of the spring:

$$P_1 = \frac{\text{H. P.}}{0.00000794DNF} \qquad (5)$$

It will at once be apparent that this is a very simple formula and one in which all of the factors necessary for the calculation of P_1 are known except F. Two designers

seldom agree exactly upon the value of the coefficient of friction even under the same conditions. There are many factors which affect this coefficient, such as speed, the normal pressure, character of surface, lubrication, materials used, etc., but in general a value of 0.1 is a conservative estimate for lubricated steel surfaces. This value substituted in Equation (5) gives,

$$P_1 = \frac{\text{H. P.}}{0.000000794DN} \qquad (6)$$

From this formula the force of the spring may be determined. In practice, it is well to increase this strength somewhat in order to make allowances for any slight error in estimation. This formula is invaluable in that it serves to prevent the use of a spring much larger or smaller than is needed to perform the work. It helps to put the designer's work on a scientific basis and enables him to avoid the cut-and-try method which is seldom justified if other means are available.

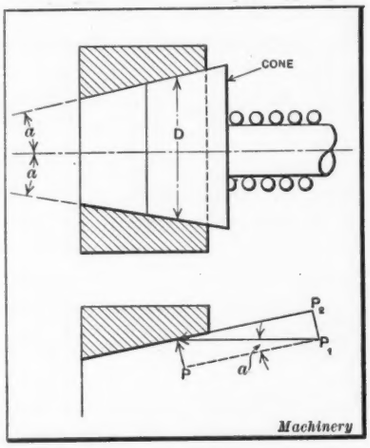


Fig. 1. Cone Clutch, and Diagram showing Relative Magnitude and Line of Action of Forces developed in Operation of a Cone Clutch

Why Several Plates are Required

The question often arises why, if friction is independent of the area of contact, it becomes necessary to use several plates, instead of simply using two plates. Theoretically, it should make no difference. Practically, however, the difference is very great, as without multiple plates the clutch would take hold so suddenly that some part would be broken or unduly strained. The thin film of oil between the plates causes them to slip upon each other for a time before they finally hold, and it is probable that some slippage is present at all times. This film should not be broken at any time because, if it is broken, the plates wear rapidly. An oil having just sufficient viscosity to maintain this film should be used. Since the viscosity decreases as the temperature rises, the maximum temperature should be considered when selecting the lubricating oil. Power is wasted if an oil having a higher viscosity than needed is used. When dry plates are used, the calculations will be the same as outlined for the lubricated plates, except that the coefficient of friction is somewhat higher, and a value of about 0.25 will generally give satisfactory results. The fact that a higher coefficient of friction is obtained with dry plates makes it possible to use a spring of less strength. Dry plates wear faster and require more frequent renewal than those running in oil, but on the other hand, they require practically no attention and are ready for service at all times until worn out.

The Cone Clutch

The cone clutch was used quite generally by early manufacturers of automobiles and is still in favor among many manufacturers. This clutch consists of a tapered circular piece called the cone, which fits into a second piece as shown in Fig. 1. One of these pieces is fastened to the driving shaft and the other to the driven. A spring placed behind the cone forces it into the other part, thus producing sufficient frictional force to drive the driven shaft. The cone is generally covered with some soft material like leather, although soft metal has been used with some success. Leather has been found very satisfactory when kept soaked with oil. The metal-lined cone clutch also requires the application of some oil. The problem is to determine the strength of the spring necessary for a clutch of this type. The forces involved and their various components are indicated in the diagram in Fig. 1. The total force is made up of numerous small forces acting along the whole surface in contact, which can all be considered as one force acting at the central point of the surface as shown. If we call the thrust of the spring P_1 as before, and the component normal to the contact surface P,

$$P = P_1 \sin a \qquad (7)$$

in which a equals the angle that the bearing surface of the cone makes with the axis, or one half the included angle of the cone. The force P_2 along the surface is:

$$P_2 = P_1 \cos a \qquad (8)$$

The horsepower formula (1) may now be applied, using as the normal force the value of P and as the tangential driving force $P \times F$:

$$P = \frac{\text{H. P.}}{0.00000794DNF} \qquad (9)$$

As P_1 is the value desired in this case, the value of P in terms of P_1 is substituted in Formula (9). Assuming for a coefficient of friction between oiled leather and cast iron a value of, say, 0.3, this formula now becomes,

$$P_1 = \frac{\text{H. P.}}{0.00000238DN \sin a} \qquad (10)$$

This equation will be found applicable to all cone clutches. The coefficient of friction used in this formula can, of course, be any value the designer determines upon, but 0.3 will

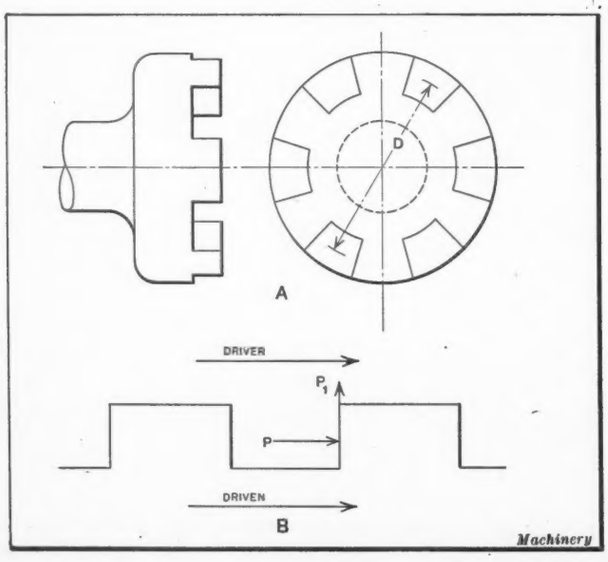


Fig. 2. Straight-tooth Clutch and Diagram indicating the Force required to mesh a Clutch of this Type

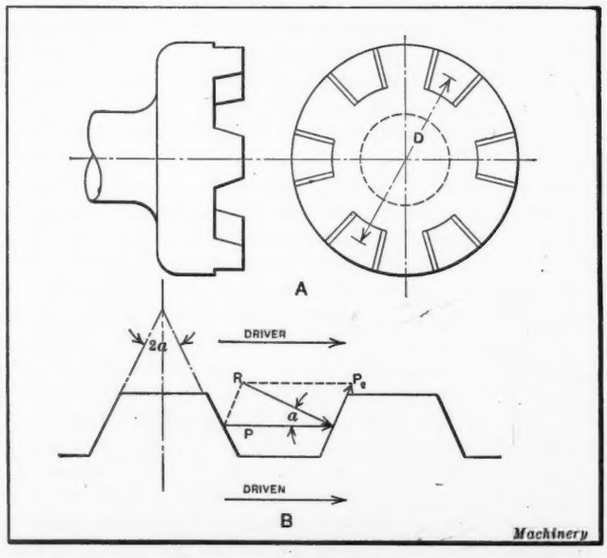


Fig. 3. Inclined-tooth Clutch and Diagram showing graphically the Forces involved in its Operation

generally give accurate results. Changing the friction coefficient changes the constant in the formula. The value of D, Fig. 1, given in the last two equations is, of course, the mean diameter of the clutch surface which is in contact, and is expressed in inches.

Positive or Toothed Clutches

Many cases arise in machine design in which it is not desired or is impossible to use a friction clutch. Such would be the case when a positive drive is required in which no slippage is permissible. If two shafts to be thus connected while in motion are in different planes and their speed is relatively slow, gears with large teeth and having plenty of clearance are sometimes employed. If the axes of the two shafts are in line, the shafts may be connected by using two couplings having radially cut teeth on their faces. Such an arrangement is used on many automobile transmissions in making the high-speed gear connection. Here one of the shafts turns at a speed determined by the speed of the car and the other at the speed of the engine. If the driver is skillful he can make these speeds equal at the moment of throwing in the high-speed gear, and the meshing will be accomplished without noise. If the two speeds are not about equal it will be either impossible to mesh them or a loud crashing noise will result. This type of clutch may also be used in other machines operated at slow speed, to connect a rotating shaft with a stationary one. The speed at which this union may be safely carried out without danger to the mechanism will depend entirely on the mass to be accelerated, that is, the weight of the parts to be set in motion beyond the clutch, and also upon the strength of the gear teeth.

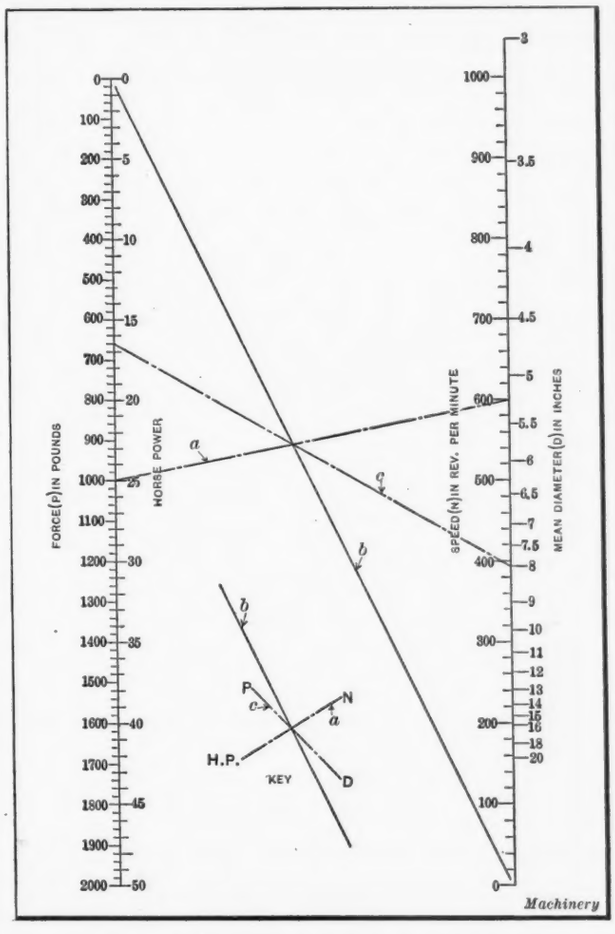


Fig. 4. Chart for solving graphically Some of the Problems pertaining to Clutch Design

At A, Fig. 2, is shown a common type of positive clutch having the teeth cut radially, and their sides parallel with the axis of the shaft. In analyzing the forces acting on these teeth, first consider them to be in mesh and the mechanism running. The result of the acting forces is obviously a driving force P as shown at B. Actually this force acts on all of the lugs, but it may be considered as concentrated at one point. In order to obtain the value of this force, the horsepower formula (2) is again employed. In this case,

$$P = \frac{\text{H. P.}}{0.00000794DN}$$

Here D represents the mean diameter of the teeth or lugs in inches. In this case the force of any spring which may be put behind the clutch to operate it is not considered. The driving force is dependent only upon the factors given in the formula.

As the driving force is the first thing to determine in the design of a clutch of this type, the writer has developed a graphical chart from which the value of P may be instantly determined without mathematical calculations. This chart is shown in Fig. 4, and the key shows how it is used. Any one of the four variables in the formula may, of course, be determined when the other three are known. Assume as an illustration that it is desired to know the driving force on the teeth of a clutch having a mean tooth diameter of 8 inches, and which must transmit 25 horsepower at a speed of 600 revolutions per minute. Draw a dot-and-dash line a connecting the numbers representing the horsepower and speed values as shown; then from the number which represents the mean tooth diameter, draw a line c through the point of intersection of line a with the diagonal line b, and extend line c until it meets the force scale. From this it is found that the driving force is about 660 pounds, and this will give the necessary value on which to base the design. In like manner any of the variables may be determined by simply following the key.

This leads to a further consideration of the resultant forces produced by the driving force. The first thing to consider is what happens if an attempt is made to separate the two parts of a coupling while the full power is on. This is exactly what is usually required, as it is customary to keep the driver running continuously. It is necessary to determine how much force must be exerted in order to do this. The required force P_1 shown at B, Fig. 2, is evidently found by multiplying the driving force P by the coefficient of friction F. Expressed in the form of an equation it would be

$$P_1 = FP$$

The coefficient of friction may safely be taken as 0.2. Assuming that at B force P is 660 pounds, the force P_1 would be $660 \times 0.2 = 132$ pounds. If separating these moving parts requires this force, meshing them together will require the same force. This force must be furnished by some outside means, usually by a spring or perhaps merely by hand power, as in the case of many machine tool drives.

Meshing Clutches by Means of a Solenoid

The solenoid is quite generally used in some types of machines to force clutches into mesh. Usually the solenoid is installed in such a way that it must compress the coil spring and at the same time overcome the friction incident to meshing the gears. When it is desired to release the clutch, the current is broken in the solenoid, and the spring forces the meshing members apart. Obviously, the spring in the example under consideration would have to exert a pressure of at least 132 pounds and the solenoid double this amount because it would not only have to overcome the force of the spring but the sliding friction in the clutch as well.

It is obvious that such an arrangement would require an unduly large solenoid coil and considerable current for its operation. The mechanism may be reversed and the spring made to connect the clutch while the solenoid breaks the connection against the compression of the spring. In either case the size of the solenoid required is the same. In the latter case the current must be on the coil all the time that the main shaft is running and the driven shaft remains idle, while in the former case the current is on only while

the clutch is in mesh. The arrangement which should be used is the one which requires the smaller amount of power; this is determined by the ratio between the time the gear is in mesh and the time it is out of mesh. Obviously such a design leaves much to be desired. Many are in use, but it is reasonable to suppose that the solenoid would be employed much more if means could be found to reduce the size of the spring and solenoid required.

Type of Clutch Especially Adapted for Operation by Solenoids

The friction force P_1, on a positive clutch, can be reduced by merely cutting the driving face of the teeth or lugs at an angle instead of parallel to the axis of the shaft. Fig. 3 at *A* shows the sloping face in a somewhat exaggerated form. Let us call the included angle of the teeth $2a$ which means that each face is at an angle a with the axis. Fig. 3 at *B* shows the force diagram, in which P is the driving force, which may be determined from the chart in Fig. 4. In this case, however, the driving force has a component P_2, along the surface of the lug, and a normal force R. If in this design the force P_2 be made equal to the force necessary to overcome friction and disengage the clutch, we would have a case of equilibrium. The force of friction in this case is not P multiplied by the coefficient of friction F, but rather the normal force R multiplied by this coefficient. Expressing this mathematically by simple equations,

$$P_2 = P \sin a$$
$$R = P \cos a$$

If $RF = P_2$, we have equilibrium.

If RF is greater than P_2, the clutch will not remain in mesh but will disengage itself.

If RF is less than P_2, the clutch will remain in mesh and an outside force P_1 will be required to release it. But this force P_1 is the one which it is desired to either eliminate altogether or at least reduce to a minimum. The condition of equilibrium should therefore be obtained in order to reduce to a minimum amount the cost of operating the solenoid. In this case, $RF = P_2$. Or by substituting the above values of P_2 and R as given in terms of the angle,

$$FP \cos a = P \sin a$$

or

$$F = \frac{\sin a}{\cos a} = \tan a$$

From the last equation it is evident that in order to have equilibrium and thereby reduce P_1 to zero, it is only necessary to make one-half of the included angle on the lugs such that its tangent is equal to the coefficient of friction. Therefore if the coefficient of friction is assumed to be 0.2, then by reference to a trigonometric table it will be found that a equals approximately 11 degrees 19 minutes. The included angle $2a$ will equal 22 degrees 38 minutes.

In making the sides of the teeth at this angle the force required (theoretically) in the spring has been reduced to zero. Actually, of course, it is not possible to do away with the spring and solenoid entirely because it is impossible to machine the parts absolutely accurate or determine the exact coefficient of friction. Following up the theoretical solution by experiments under various conditions will readily give the desired results. After the angle has been determined and experiments made to ascertain the force required to engage and disenage the clutch, it is only necessary to install a spring sufficiently large to overcome slight irregularities resulting either from imperfect machine work or an error in our estimate of the coefficient of friction, as previously mentioned. The spring will, of course, be under compression while the clutch is held in mesh by a small solenoid. When the current in the coil is broken, the small spring will release the clutch. In the first case, in which the teeth were cut straight, the spring was required to exert a force of over 132 pounds, while in the latter case, a spring capable of exerting about 10 pounds will be sufficient to do the work if the angle is properly determined; therefore, a much smaller spring and solenoid will be required. The saving in space may be as important as the reduced cost of operation or the saving resulting from the use of smaller and less expensive springs and solenoids.

Referring to the diagram *B*, Fig. 3, there at first appears to be a fallacy in the theory advanced in connection with the inclined-plane clutch design. It will be noticed that nothing has been said about the meshing process in the last case as regards the forces involved. It is evident that the solenoid must be somewhat stronger than the spring and according to the original theory the force required to mesh these two parts of the clutch would be found to be exactly the same as when the teeth were cut straight, or in this case, 132 pounds. It would appear that the solenoid not only must overcome the sliding friction expressed in this case by $R \times F$ but also the component of the driving force P_2. The question then arises as to how the small solenoid can bring the clutch into mesh, as it appears that a large force is required to mesh the clutch and practically no force to release it.

This is not the case, however, and while this reasoning seems perfectly sound theoretically, it does not make allowance for other factors which must be considered when the engaging operation takes place. The sliding part of the clutch which is not rotating when out of mesh must move some distance before the teeth engage. During this movement the sliding members gather speed and store up energy. Considerable clearance is, of course, always allowed between the teeth on one part and the space on the other when the clutch is disengaged. When the teeth finally meet during the meshing process, the friction force, as well as the component of the driving force, comes into play to retard the meshing. This consumes the energy which has been previously stored in the sliding part, and when this energy has been all absorbed the meshing will stop. However, the depth of the teeth is never great, usually only a fraction of an inch, and thus the energy stored up in the sliding member is sufficient to mesh the clutch teeth properly.

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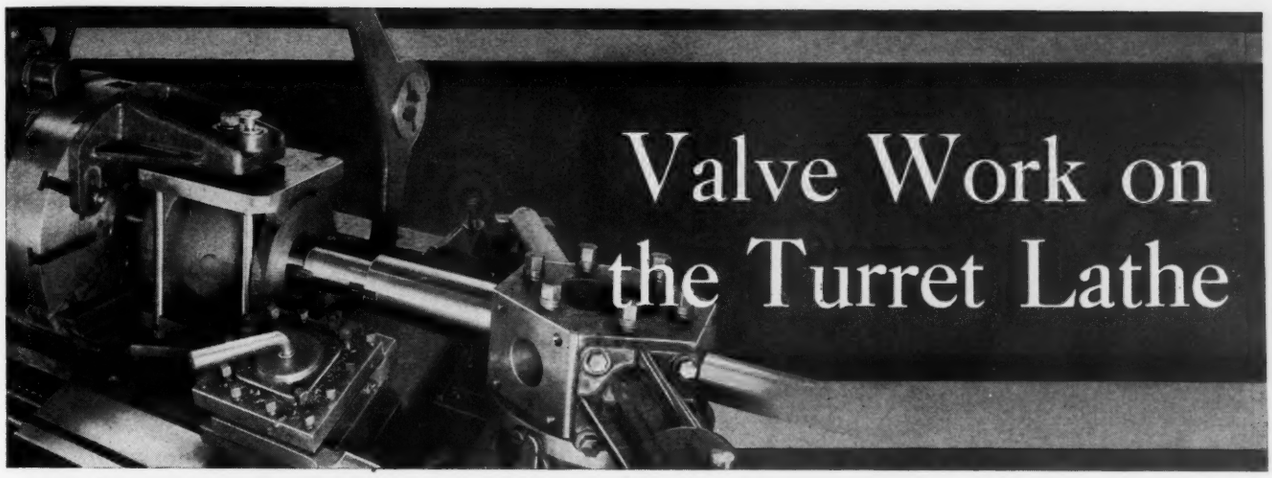
AN ACCIDENT "THERMOMETER"

The safety department of E. I. du Pont de Nemours & Co., Wilmington, Del., has devised what is known as an "accidometer," which is simply a large bulletin board to which has been attached what may be termed accident "thermometers" for the various departments to which this bulletin applies. Above each thermometer is given the name of the foreman of the department together with names of the subforemen responsible to him. The number of accidents in each department is then indicated by the height of the black line in each thermometer. Suitable awards are given to the foremen and general foremen who have a clear record, or no serious accidents, during the preceding six or twelve months. It has been found that this method of making a comparison between the safety in the various departments appeals strongly to the workman's sense of loyalty to his foreman and to his department. The safety department reports that a great deal of rivalry has been created and a keen interest in accident reduction has become apparent.

* * *

Special Trade Commissioner Burwell S. Cutler, of the Department of Commerce, Washington, D. C., stated in an address recently made before the American Manufacturers Export Association at Chicago that the great loss of men in Germany due to the war has not materially affected the ranks of trained labor in the mechanical industries, because that class of labor was largely withdrawn from the Army and placed in the factories for the manufacture of war supplies. Many lines of industrial workers were thus exempt, if the industry was considered necessary to the successful conduct of the war or the maintenance of the civil population. Hence, as soon as the economic conditions of Germany have been somewhat readjusted, it may be expected that Germany will enter into industrial competition with the rest of the world in a very effective manner, and manufacturers of other nations must be prepared to meet that competition.



Valve Work on the Turret Lathe

A Review of Different Methods for Holding and Machining Valves on the Turret Lathe, Based Upon the Practice of the Gisholt Machine Co., Madison, Wis.

By ERIK OBERG

IN finishing valves on the turret lathe, there are four methods by means of which the valves may be held, according to the class of valve operated upon and its dimensions. Fig. 1 shows the method used for holding small valves. As will be seen, the valves are simply held by special chuck jaws bearing against the flange at one end of the valve, while clamps are provided binding down upon the top of the flange, and thereby holding the valve securely in place. In the case of small valves, no further support is required.

Fig. 2 shows the swivel-fixture method as it is applied for holding a small valve. An enlarged view of the holding device is shown in Fig. 3. It will be seen that special supporting arms or angle-plates are used, extending from the face of the chuck; the valve is held between two of these arms. Strictly speaking, this is a special fixture of simple design. The valve is finished complete while it is held in this fixture, being so mounted that it can be swiveled to present different flanges to be faced to the tools.

For larger valves of similar construction, a swiveling fixture of somewhat different design, but similar in principle, is used, as shown in Fig. 4. This fixture is also so arranged that the valve can be indexed around to machine the two flanges, but as a rule the valve seat is not machined in this fixture; instead it is machined by holding the valve on a threaded arbor which enters it at the end opposite the valve seat, this end being tapped to fit the threaded arbor or stud, so that the valve may be held as shown in Fig. 5, which illustrates the third method. This method, of course, can only be used when there is a hole that extends entirely through the valve. The advantage of this method of finishing the valve seat is that in cases where valves have to be reseated in the field, they may be screwed on an arbor, and will then be sure to run true.

The fourth method for holding valves for machining in a turret lathe is shown in Figs. 6 and 7, which illustrate a special fixture or angle-plate that is employed for valves of irregular shape and for which, therefore, a swiveling fixture such as shown in Fig. 4 cannot be employed. Fig. 6 shows the fixture before the valve is put in place, and Fig. 7 shows the same fixture with the valve in position and the supporting or clamping arm at the top in place. It will be noted that the arm has a roller at the top, bearing against the rotating part of the fixture in which the valve is clamped. Rollers are also provided (as will be seen in Fig. 6) at the sides, held in holders clamped to the vees of the machine. In this way, the outer end of the fixture is thoroughly supported. Examples showing the order of operations with valves held by the different methods will now be shown.

Tooling Equipment for Small Valve Held in Chuck Jaws

Fig. 8 shows a valve being held by the first method described for machining in a 21-inch Gisholt turret lathe. This is a three-way valve, having three flanges to be machined. The material is cast iron. The first operation consists of chucking the valve by the same method as shown in Fig. 1, the valve being held with special hard jaws by one flange, while the flange at the opposite end is faced by a tool held in the toolpost, as shown in Fig. 8. The time for the chucking and finishing of this end is 5 minutes.

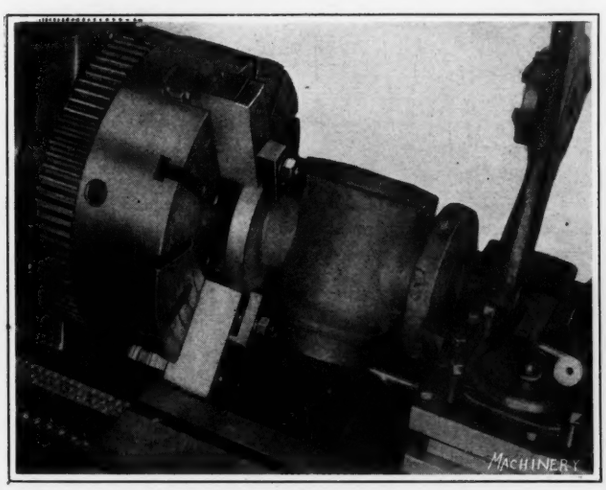


Fig. 1. Method used for holding Small Valves

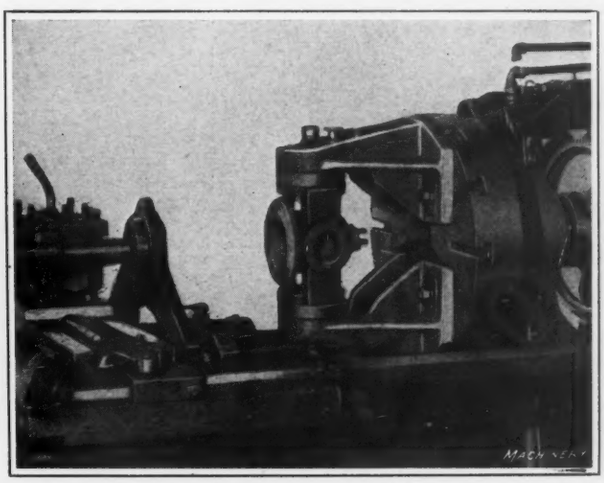


Fig. 2. Swivel-fixture Method of holding Small Valves

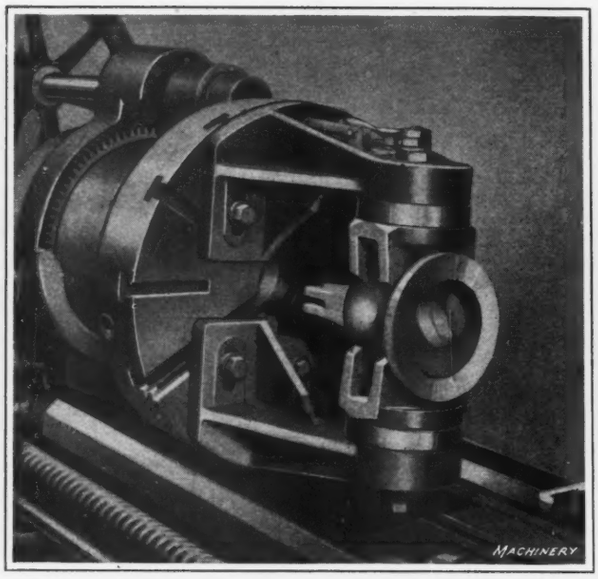


Fig. 3. Enlarged View of Holding Device shown in Fig. 2

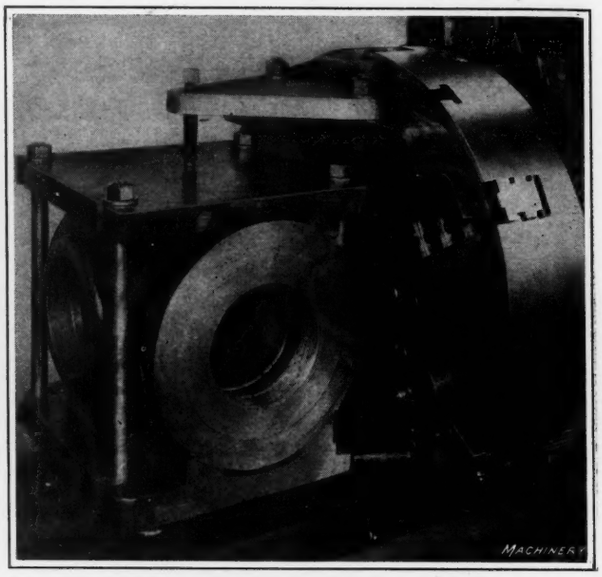


Fig. 4. Swivel Fixture used for holding Large Valves

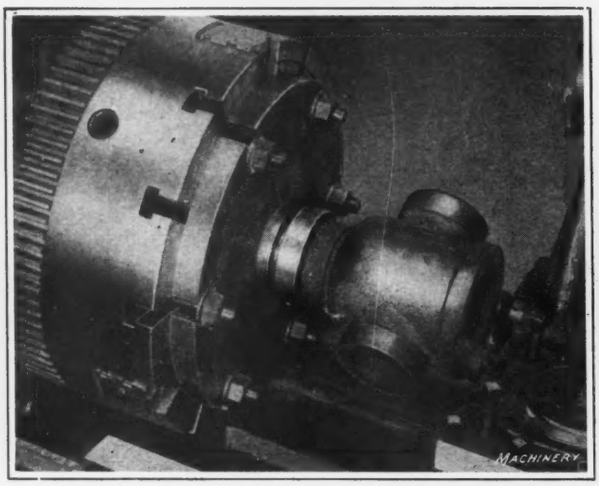


Fig. 5. Threaded Arbor or Stud used for holding Valve

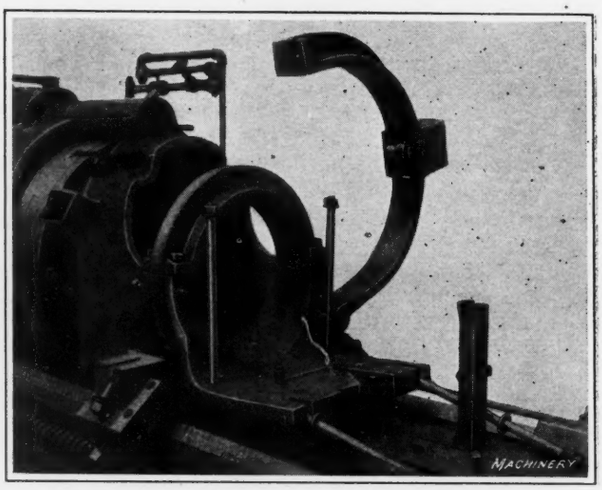


Fig. 6. Angle-plate Fixture for Valves of Irregular Shape

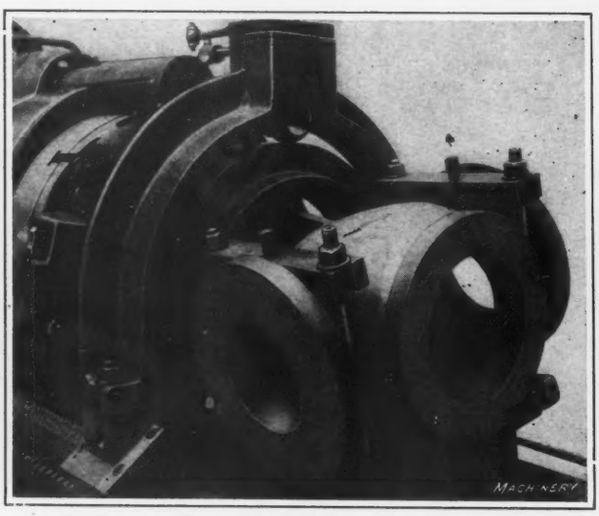


Fig. 7. Fixture shown in Fig. 6 with Work in Place

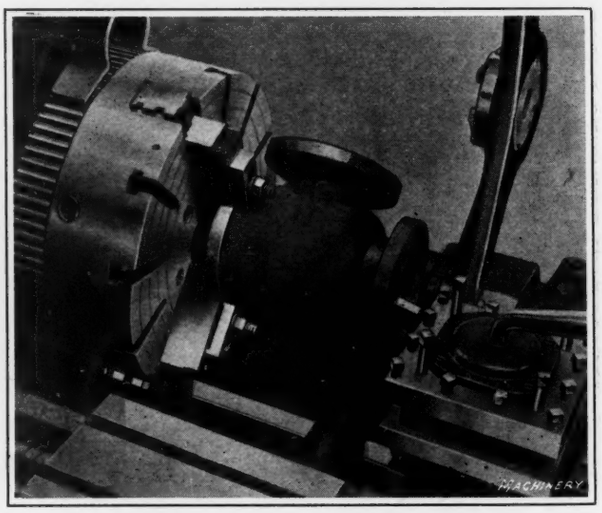


Fig. 8. Three-way Valve held by Method shown in Fig. 1

The second operation consists of holding the valve by the finished flange, while the opposite flange is machined. The time for performing this operation is 6 minutes.

The third operation, as illustrated diagrammatically in Fig. 9 and by the halftone illustration, Fig. 12, consists of finishing the face *C* with a tool in the toolpost, the valve being held on an angle-plate provided with a centering collar. A counterweight is used on the faceplate to balance the weight of the angle-plate. Uprights are provided under the flange being finished, through which screws pass, supporting the flange as shown in Fig. 12. The time for the third operation is 7 minutes.

Instead of finishing the valve at *C* by holding it by chuck jaws, as indicated in Figs. 1 and 8, the valve may be tapped at one end and held on a stud, as illustrated in Fig. 5 and as shown diagrammatically in Fig. 10, the object of finishing

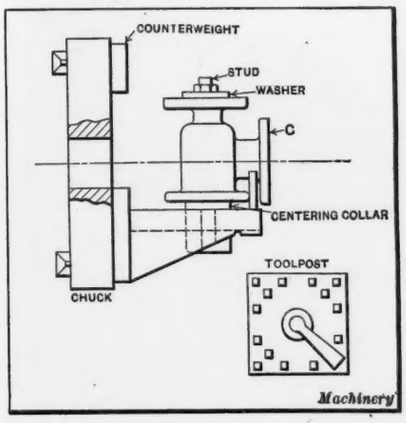


Fig. 9. Third Operation on Valve shown in Fig. 8

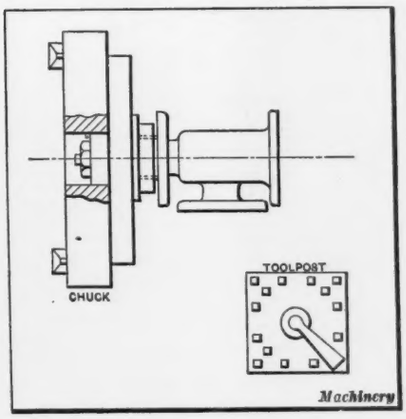


Fig. 10. Method used for holding Valve on Stud

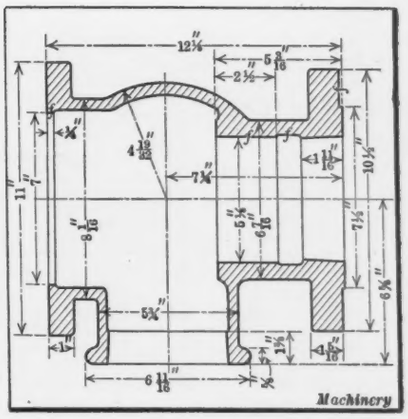


Fig. 11. Cross-sectional View of Cast-iron Globe Valve

the valve seat in this manner having already been explained. In that case, the operation consists in screwing the valve on the centering stud and facing the opposite flange. The total time for this operation is 5 minutes.

Equipment for Machining a Globe Valve

Fig. 11 shows a cross-section of a cast-iron globe valve finished on a 24-inch Gisholt turret lathe. The lay-out of the tooling equipment is shown in Fig. 14, while Fig. 13 shows the fixture in which the valve is held while being machined. This fixture is of the swiveling type, so that the valve can be turned around for machining the different flanges. Two views of the fixture are shown in Figs. 15 and 16, the illustration, Fig. 16, showing the faceplate turned around 90 degrees from the position in Fig. 15 so as to clearly show the construction of the swiveling fixture. Fig. 17 shows the machine with the complete tooling equipment required, corresponding to the lay-out in Fig. 14.

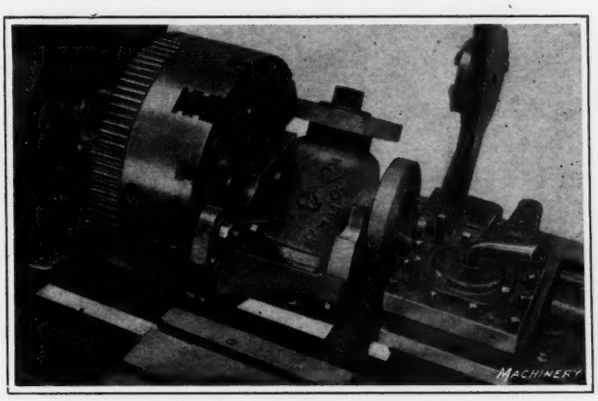


Fig. 12. Machine set up for Third Operation on Valve in Fig. 8

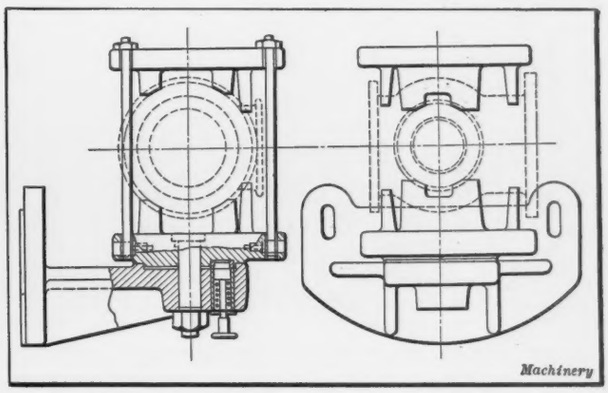


Fig. 13. Fixture in which Valve in Fig. 11 is held while being machined

The step-by-step order of operations is as follows (see Fig. 14): (1) The valve is placed between the angle-plates, being held in a special cradle as shown in Figs. 13, 15, and 17. (2) Hole *A* is rough-bored with a cutter held in the bar that is mounted in Side 1 of the turret. (3) Hole *A* is finished with a cutter held in the bar mounted in Side 5 of the turret. (4) Hole *A* is tapped with a tap held in Side 2 of the turret. After having completed the tapping, the fixture, with the valve in it, is turned around one-quarter turn. (5) Flange-faces *D* and *E* are rough-faced with tools *K* held in the toolpost. (6) Hole *C* is rough-bored with a cutter held in the bar in Side 4 of the turret. (7) Hole *C* is finished with a cutter mounted in the bar held in Side 5 of the turret. (8) Faces *D* and *E* are finished with tools *L* in the toolpost. (9) Recess *B* is bored out with tool *M* in the toolpost. (10) Hole *C* is tapped with the tap mounted in Side 2 of the turret. The total time required for the various steps of this operation is 15 minutes.

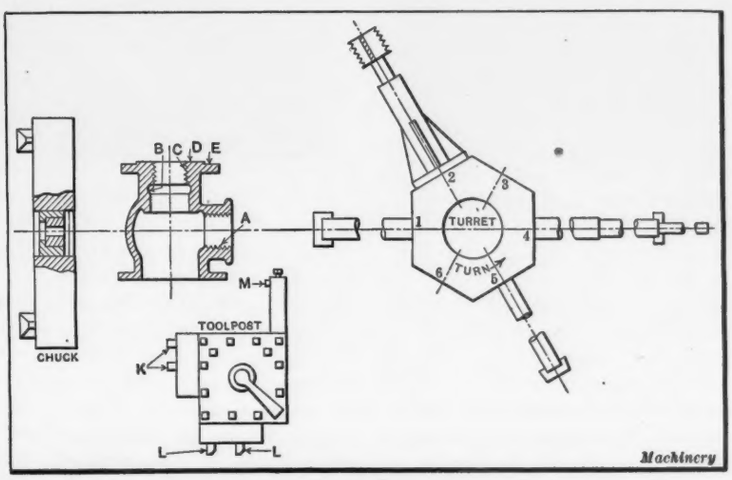


Fig. 14. Tooling Equipment for Valve shown in Fig. 11

The second operation, a detail view of which is shown in Fig. 20, consists of facing and boring the valve seat. In this case, the valve is held on a threaded center plug, as indicated in Fig. 18 and as shown more clearly in Figs. 19 and 21. Fig. 18 shows the complete tooling equipment set up on the machine. The step-by-step operations are as follows (see Fig. 21): (1) The valve is screwed on the center plug. (2) Flange *I* is rough-faced with tool *N* in the toolpost. (3) Holes *F* and *G* are rough-bored with cutters *O* and *P*, respectively, held in the boring-bar mounted in Side 1 of the turret. (4) Shoulder *H* is faced with tool *R* held in the toolpost. (5) Holes *F* and *G* are finished with cutters *S* and *T*, respectively, held in the boring-bar mounted in Side 3 of the turret. (6) Hole *F* is reamed with the reamer mounted in Side 5 of the turret. (7) Flange *I* is finish-faced with tool *U* held in the toolpost. The

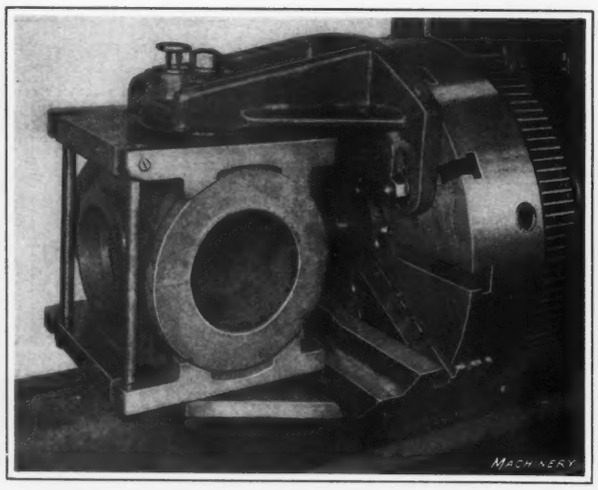


Fig. 15 Fixture shown in Fig. 13 mounted in Machine

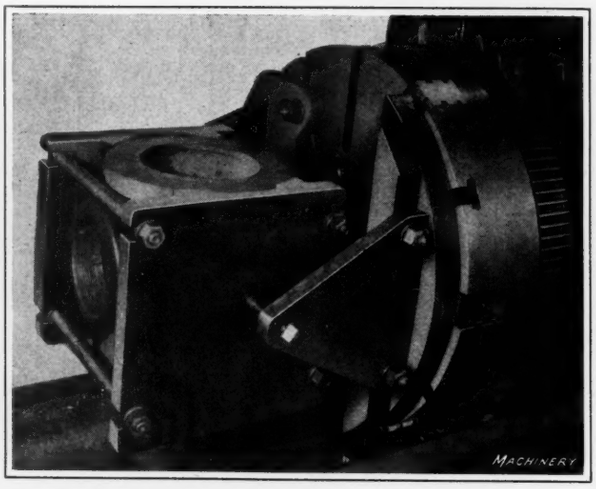


Fig. 16. Faceplate turned around 90 Degrees from Position in Fig. 15

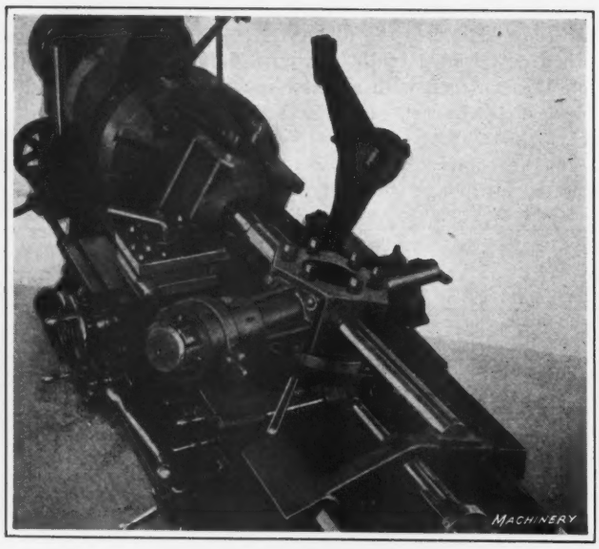


Fig. 17. Machine with Complete Tooling Equipment for finishing Valve shown in Fig. 11

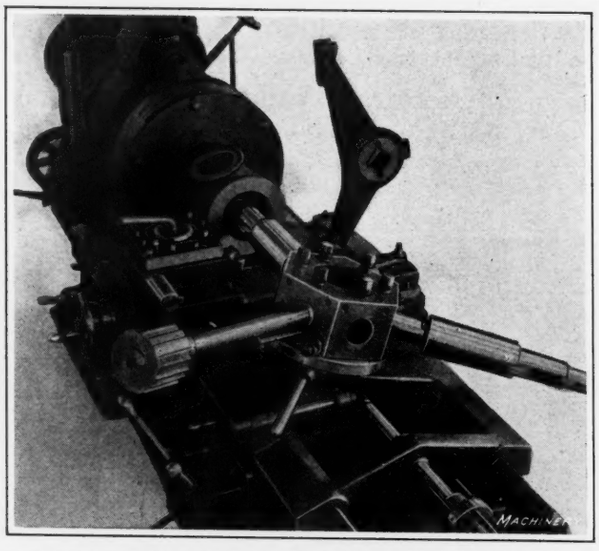


Fig. 18. Machine set up for Second Operation on Globe Valve shown in Fig. 11

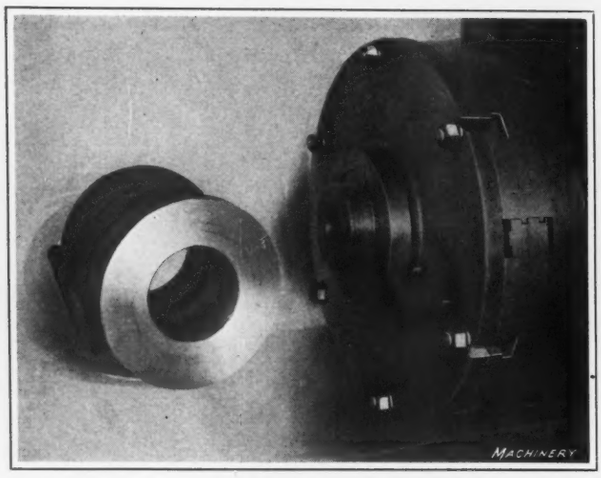


Fig. 19. Illustration showing Threaded Center Plug on which Valve is held for Second Operation

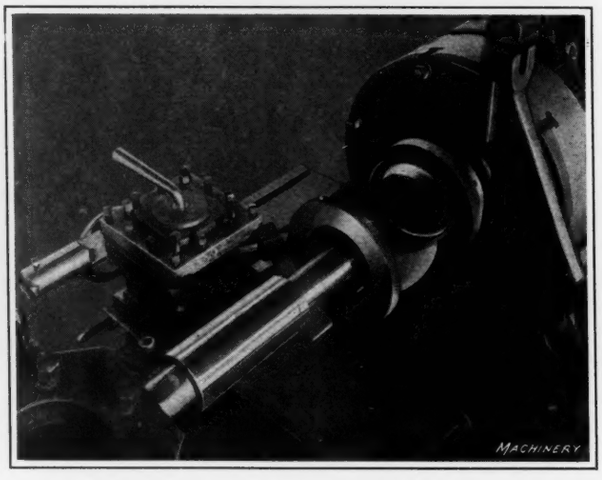


Fig. 20. A Detail View of the Second Operation on the Globe Valve shown in Fig. 11

total time required for the second operation on the globe valve is 8 minutes.

The examples given show quite clearly the four different methods that can be used to advantage for finishing valves on the turret lathe. In laying out the tooling equipment, the tool designer must, of course, decide in which case each one of the four methods can be most advantageously applied to the valve under consideration. The size of the valve has first to be taken into account, as it would not be possible to hold a large heavy valve, having a great deal of overhang, in the same way as a small and light valve could be clamped. Valves with irregular outline also require special fixtures as shown, and the tool designer sometimes must exercise considerable ingenuity in designing the simplest possible holding means that will still make it possible to obtain the accuracy aimed at and the production required. Difference in the time needed to finish a valve when a proper holding fixture is used, as compared with the time when a fixture of cumbersome or unsatisfactory design is employed, is very marked. Users of turret lathes on valve work should, there-

fore, thoroughly study the different methods used in connection with this work, noticing the four different means outlined in the present article with a view to obtain a guide for the selection of the best means in each case. That the productive capacity of the turret lathe depends very largely upon the efficiency of the tooling equipment and the careful selection of the means for holding the work, is evident; nevertheless, this fact is not appreciated by turret lathe users as much as it should be, and hence it is necessary that special emphasis be placed upon this point.

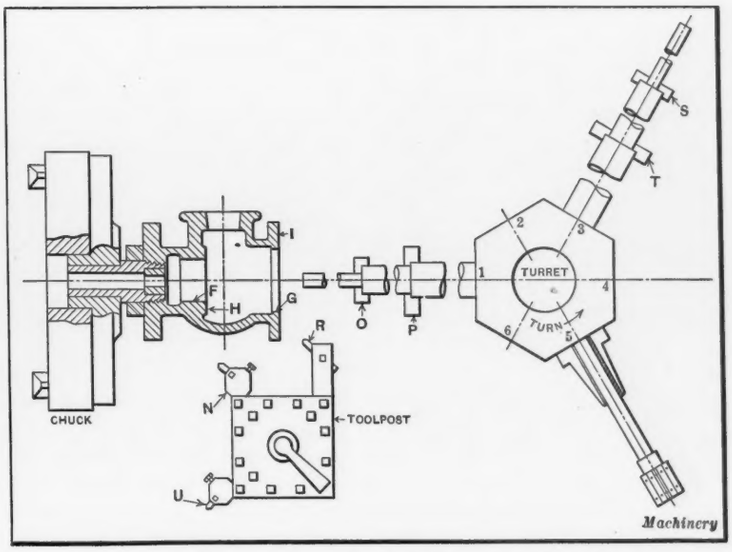


Fig. 21. Tool Lay-out for Second Operation on Globe Valve

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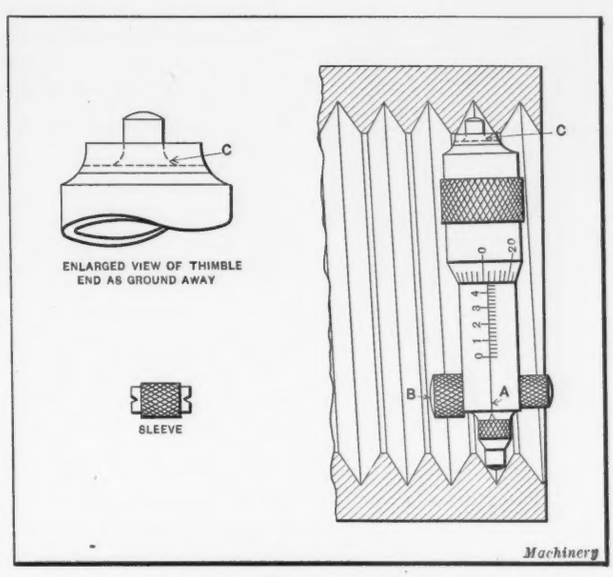
IMPROVEMENT IN INSIDE MICROMETERS

By WILLIAM S. ROWELL

It is interesting to note how few changes have been made in the design of inside micrometers above 2 inches in size during the last fifteen years. The writer has a set, however, in which several interesting features have been incorporated, and which have been tried and proved entirely satisfactory. Referring to the accompanying illustration, it will be seen that the reading line has been extended the full length of the hub, as at *A*. This makes the reading more easily taken when the thimble covers the zero mark or when the light is poor. Another slight improvement over the standard design is that the rod-clamping screw *B* is provided with a head which is about twice the diameter of its little used mate. This identifies it and provides better contact for thumb and finger when clamping the measuring rod. The sleeves are notched at both ends, furnishing dust grooves at each end no matter which way they are put on the rods.

The fact that the head of the thimble comes so close to the contact point in the standard micrometer, has led to a slight change in the thimble, which is shown by the dotted line *C* in the illustration. It will be seen that a portion of the thimble has been ground away to provide for clearance. This improvement is very noticeable when gaging shallow counterbores, in starting cuts, and in duplicating inside threads. When the diameter and pitch of thread will admit the insertion of the micrometer, as shown in the illustration, a fairly accurate means is provided for duplicating an internal thread. It will be noticed that the rod end of the micrometer is properly entered in the thread groove, while the thimble end cannot contact with the sides of the thread owing to the shortness of the small diameter portion. However, by grinding away as indicated by the dotted line, this end also will contact on the sides of the thread. A slight difference in the diameters of the contact points is an advantage, because it enables measurements to be made from two parts of the angular sides of the thread groove. To avoid trouble with wrench flats on contact points, they should be coned to a somewhat smaller angle than that of the thread groove angle; for instance for a 60-degree thread, an included angle of possibly 50 degrees is about right. It is evident that this angle overcomes any interference that might result from the diagonal position of the micrometer when taking the measurement.



Position of Inside Micrometer when measuring Internal Threads, showing Advantages of Minor Improvements

When used to measure the diameter of a hole, it is not advisable to set the micrometer to a predetermined size, but rather to adjust it to the bored size, reading the result from the graduations on the hub. Some users, however, obtain the reading by repeated settings outside the bore and repeated trials within. A better way is to set the micrometer slightly above the actual diameter of the bore; place the measuring rod in the bore to be measured; and then bring the thimble end as nearly diametrically opposite as the length of the micrometer will permit. Use the end of the second finger against the clamp screw as a stop to prevent the head from turning when adjusting the thimble with the thumb and forefinger. With a little practice, measurements can be taken in this manner quickly and accurately.

* * *

Stevens Institute of Technology has conferred the degree of Doctor of Engineering upon Charles Eugene Schneider, president of the French Industrial Commission to the United States and the head of the Creusot Iron Works, comprising a chain of thirty industrial and manufacturing plants in France. Mr. Schneider is noted as the engineer who produced the well-known 155- and 240-millimeter howitzers that were used so successfully during the war, as well as the railway mounts for large caliber guns, advantageously used in the war by the French Army and adopted by the American Government for its ordnance. On his visit to the United States, Mr. Schneider was especially impressed by the great attention that was given to engineering schools and colleges.

* * *

It is announced that the government of Italy has taken steps to develop systematically industrial experiment stations and technical educational facilities. The introduction of the eight-hour day in many industries, it is stated, has rendered this step necessary, as with the reduction in hours, increased efficiency must be brought about if production is to be maintained.

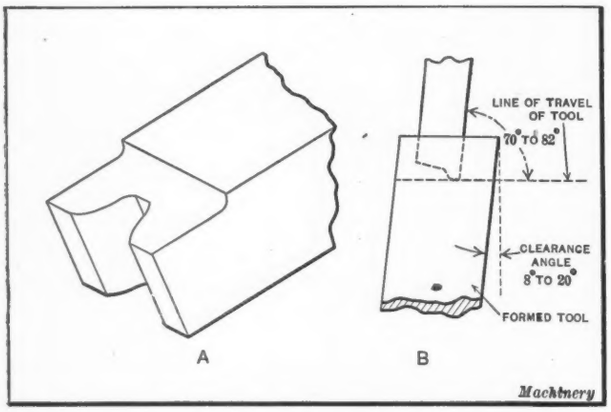


Fig. 1. (A) Formed Tool used in Backing-off Lathe. (B) Diagram indicating how the Formed Tool is planed to Shape by Formed Shaper Tool

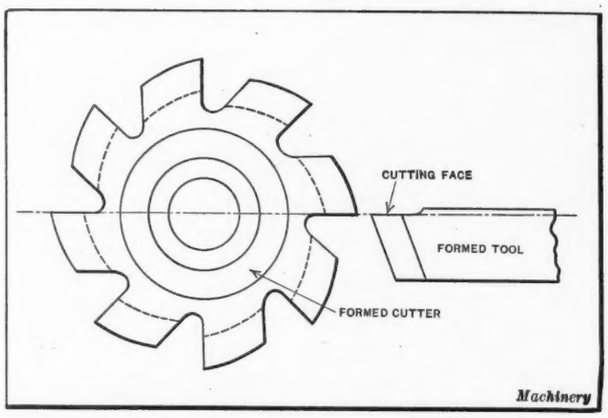


Fig. 2. Relative Positions of Formed Tool and Formed Cutter when backing off Circular Forming Tools and Formed Milling Cutters

Formulas for Formed Tools

Angular Position of Tools Used for Planing Formed Tools—Calculations for Making Circular Tools Used on Automatic Screw Machines

By W. E. THOMPSON

FORMED tools such as shown at *A*, Fig. 1, are used principally on lathes equipped with backing-off or relieving attachments in order to produce circular forming tools and formed milling cutters. These formed tools are usually shaped either in a milling machine by using a fly cutter of the required outline, or by means of a shaper equipped with a form tool having the exact contour of the piece or part to be produced. When the latter method is employed, a special clapper fixture is used which allows the shaper tool to be held in the required angular position. The method of determining the angle to which the shaper tool should be set to meet various requirements is described in the present article.

Formed tools properly shaped by accurately formed shaper tools may be ground on their cutting faces without changing their form. They are always set in the lathe with this face in a plane passing through the axis of the cutter or circular tool, as shown in Fig. 2, but the circular cutting tool may or may not have its cutting face or faces in this plane. Formed circular tools, or cutters shaped with a formed tool may also be ground on their cutting faces without changing their form.

Angular Position of Tools when Planing Formed Tool

First let us consider the case of formed milling cutters having their cutting faces in radial planes, which are to be produced by formed tools planed to the required shape by a formed shaper tool. When planing the formed tool, the cutting faces of the formed tool and the shaper tool are held in parallel planes, usually at an angle of 70 degrees with the line of travel of the fly cutter—20 degrees being the usual clearance angle for formed tools used for backing off the teeth of milling cutters. The relative positions of the tools are clearly shown at *B*, Fig. 1. The cutting face of the shaper tool, which has the exact dimensions and form of the work to be produced, thus accurately shapes the formed tool so that it will produce milling cutters or circular forming tools of the required shape.

When making circular forming tools of irregular outline for automatic screw machines, or formed milling cutters having other than radial cutting faces, the cutting face of the shaper tool is set at an angle with the cutting face of the formed tool as shown in Fig. 3, instead of parallel with it. This angle *c* depends upon the distance of the cutting edge of the circular tool or cutter below the center, and in the case of screw machine tools the two following conditions are to be considered:

1. When the face of the circular tool is set in a radial plane of the work.
2. When the face of the circular tool is set at an angle to a radial plane of the work in order to obtain top rake.

The first condition is comparatively simple to deal with,

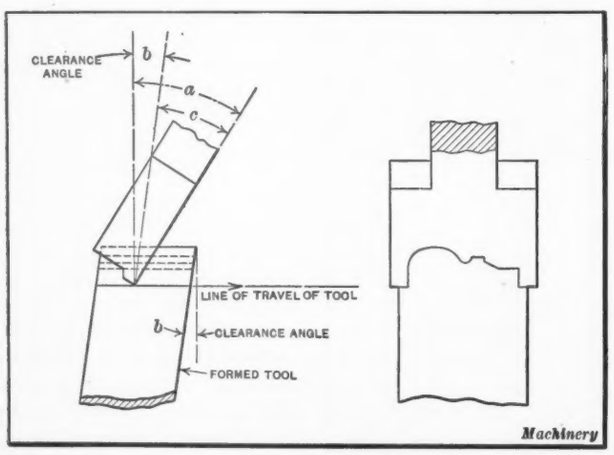


Fig. 3. Diagram showing how Shaper Tool is set to produce Formed Tool of Irregular Outline

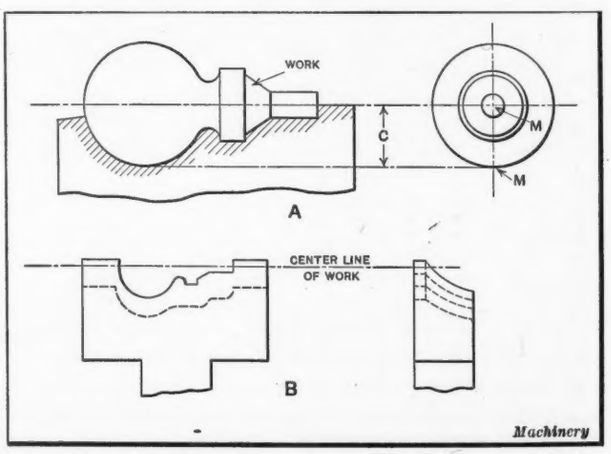


Fig. 4. (A) Work to be produced in Screw Machine; (B) Shaper Tool for shaping Forming Tool used in Screw Machine

and considerable data have been published concerning this form of tool; but the exact formula for calculating the shaper tool setting is not always readily found, and for this reason it will be given herewith. The second condition presents more complications, but the formula which has been derived to meet this condition is quite easy to apply, as it has been reduced to a simple form.

The formulas used in designing formed tools for backing off cutters having top rake on their cutting faces, or as they are commonly termed, hook-tooth cutters, are not generally known, and as similar difficulties are presented in computing the angle of correction c of the shaper tool, they are also given here in simple form.

Making Formed Tool for Screw Machine

The view at A, Fig. 4, represents a part to be produced in a screw machine. The dimension C is the working depth of the tool measured on a radial line. It should be mentioned here that the letter C is used exclusively throughout the present article to represent the working depth of formed tools or cutters. At B is shown the shaper tool employed to plane the forming tool required to produce the circular cutter. This tool, having the outline of the part shown at A as determined by the radial cutting plane M–M, is provided with a shank which permits it to be held in the tool-holder of the shaper.

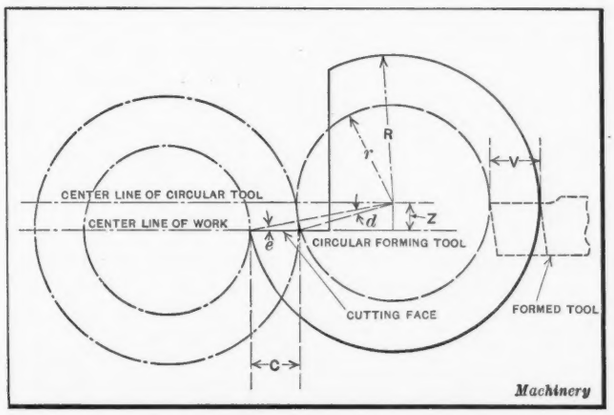


Fig. 5. Relative Positions of Work to be formed, Circular Forming Tool, and Tool used to produce Forming Tool

Fig. 3 shows the relative position of the shaper tool and formed tool when planing the formed tool for making a circular forming tool having the cutting face in a plane other than radial, or a hook-tooth cutter. The angle a, at which the face of the shaper tool is set, equals the clearance angle b, plus the angle of correction c. For formed tools used to produce cutters having a radial cutting face, the face of the shaper tool is set at the clearance angle b only, as stated before and as illustrated at B, Fig. 1.

Calculations for Making Circular Forming Tool

The diagram Fig. 5 represents a circular forming tool having its cutting face in a radial plane of the work. Certain dimensions must be known and tabulated in all cases in order to determine the required angular position of the shaper tool, and in this case we have given the outside radius of the circular tool; the working depth of the cut, which is taken from the work specifications; the distance of the cutting face below the center of the circular tool, which varies from ⅛ to ½ inch, depending upon the size of the tool; and the clearance angle of the formed tool. These known quantities are represented by letters as follows:

R = outside radius of the circular tool;
C = working depth of cut (Fig. 4);
Z = distance of cutting edge below center of tool;
b = clearance angle of formed tool (Fig. 3).

The unknown dimensions on the diagram Fig. 5 are represented as follows:

r = radial distance from center of tool to the inside of cutting form on cutting face;

V = actual length of form of formed tool, which is set in a radial plane of the circular tool. This distance is equal to $R - r$ and is less than the distance C.

The construction lines forming angles d and e are drawn for the purpose of calculating r.

$$\text{Sin } e = \frac{Z}{R}$$

$$\text{Tan } d = \frac{C \sin e}{R - (C \cos e)}$$

$$r = \frac{C \sin e}{\sin d}$$

$$V = R - r$$

Fig. 6 presents a diagram and a formula for determining the angle a previously referred to and illustrated in Fig 3. Thus in shaping a form tool for use in making a circular forming tool the shaper tool is set at an angle a which is determined by the formula,

$$\cos a = \frac{V \cos b}{C}$$

The second condition is represented by the diagram Fig.

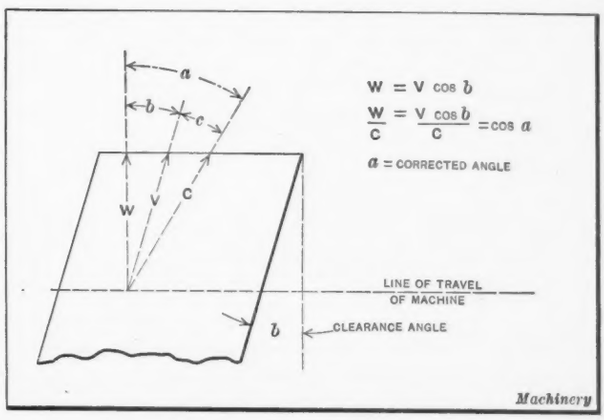


Fig. 6. Diagram showing Method of deriving Formula used to determine Shaper Tool Setting

7, which shows a circular tool having its cutting face at an angle with a radial plane of the work that passes through its highest point. The known values are tabulated as in the preceding case:

b = clearance angle of formed tool (Fig. 3);
R = outside radius of work;
r = inside radius of work = $R - C$;
e = angle of rake, or the angle that the cutting face of the cutter makes with a radial plane of the work passing through the highest point of the cutting edge;
Z = distance that highest point of cutting edge is below center of circular tool;
R_1 = outside radius of circular tool.

Construction lines are drawn as illustrated for the purpose of solving the following formulas:

$$\text{Sin } A = \frac{r \sin e}{R} \qquad (1)$$

$$S = R \cos A - r \cos e \qquad (2)$$

$$\text{Sin } f = \frac{Z}{R_1} \qquad (3)$$

$$g = f + e \qquad (4)$$

$$\text{Tan } d = \frac{S \sin g}{R_1 - (S \cos g)} \qquad (5)$$

$$r_1 = \frac{S \sin g}{\sin d} \qquad (6)$$

$$V = R_1 - r_1 \qquad (7)$$

Again referring to Fig. 6,

$$\text{Cos } a = \frac{V \cos b}{C} \qquad (8)$$

Calculations for Making Hook-tooth Cutter

An entirely different condition is found in Fig. 8, where the relation of a hook-tooth cutter to its formed tool is shown. In this case the face of the formed tool moves in a straight radial line toward the center of the cutter a given distance and returns to its starting position once during the rotation of the cutter through each tooth space. Referring to the diagram, it will be seen that the working depth V of the formed tool, will be less than the working depth C of the cutter due to the movement of the tool and the angularity of the cutting faces. The known quantities are as follows:

R = outside radius of cutter;

r = inside radius of cutter; $r = R - C$;

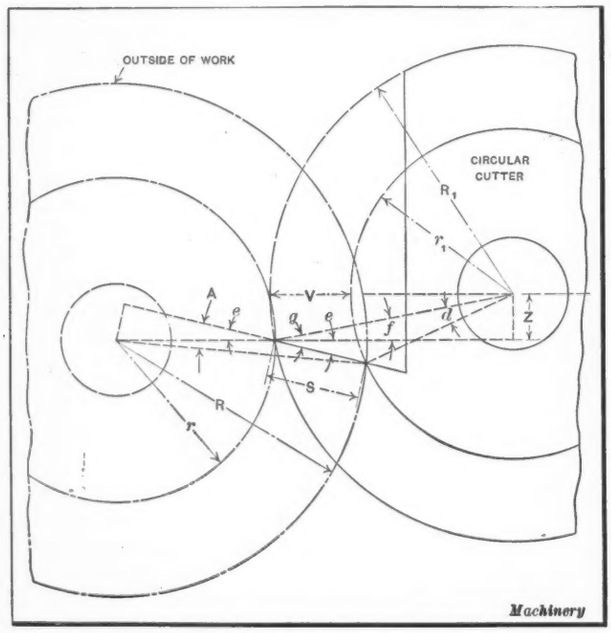


Fig. 7. Diagram used in determining Shaper Tool Setting when a Circular Formed Cutter is required which has its Cutting Face at an Angle with a Radial Plane of the Work

Z = distance of cutting edge behind center; $Z = R \sin e$

e = angle of cutter rake; $\sin e = \frac{Z}{R}$

N = number of teeth in cutter;

P = drop of backing-off cam, or distance that formed tool moves in one direction during advance of one tooth space in rotation of cutter;[1]

b = clearance angle of formed tool.

It will be seen by referring to the diagram Fig. 8 that the formed tool starts to cut on the line OM, but does not cut on its entire form until the cutter has revolved through an angle h, when the plane represented by OQ coincides with the cutting face of the formed tool. At this stage of the cycle of movements the tool has moved toward the cutter center a distance represented by x; therefore the formed tool must have a working depth equal to V, or in other words equal to $C - x$.

Using the known quantities, we have:

[1]It is customary to allow 1/8 of the tooth pitch for the return movement of the backing-off tool. The tool thus has its full forward movement in 7/8 of the tooth pitch which is stated in angular terms thus: $\frac{360}{N} \times 7/8 = \frac{315}{N}$ degrees. Then $\frac{315}{N}$ degrees equals the angular movement of the cutter while the forming tool makes its extreme movement forward. If the cam used to reciprocate the formed tool is made to return in more than 1/8 of the tooth pitch, this equation must be changed to suit the condition.

$$\text{Sin } f = \frac{R \sin e}{r} \qquad (1)$$

$$h = f - e \qquad (2)$$

$$x = \frac{NPh}{315} \qquad (3)$$

$$V = C - x \qquad (4)$$

Referring to Fig. 6,

$$\text{Cos } a = \frac{V \cos b}{C} \qquad (5)$$

The face of the shaper tool is set at the corrected angle a when planing the formed tool form.

Example of Hook-tooth Computation

Let $R = 2$ inches; $r = 1.5$ inches; $e = 15$ degrees; $N = 10$; $P = 0.200$ inch; and $b = 15$ degrees. Substituting these values in the preceding formulas we have:

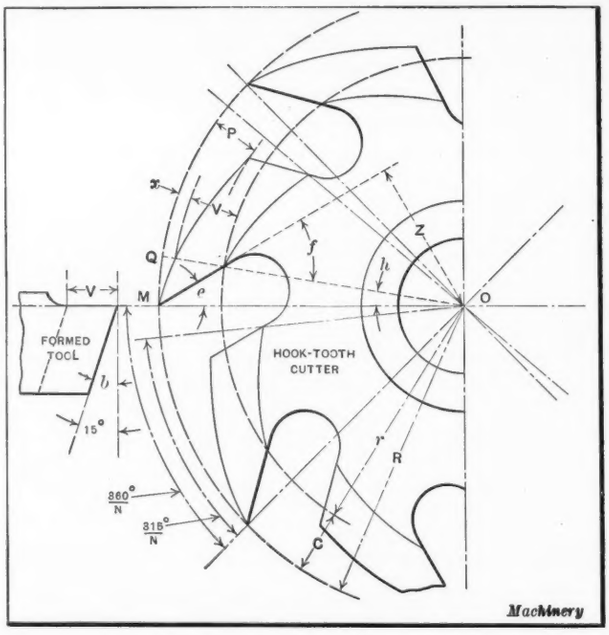


Fig. 8. Lay-out of Hook-tooth Cutter required to evolve the Formula employed in determining the Angle at which Shaper Tool is set

$$\text{Sin } f = \frac{2 \times 0.25882}{1.5} = 0.3451 \qquad (1)$$

Therefore angle $f = 20$ degrees 11 minutes

$h = f - e = 20$ degrees 11 minutes $- 15$ degrees $=$ 5 degrees 11 minutes (2)

$$x = \frac{10 \times 0.200 \times 5 \text{ degrees } 11 \text{ minutes}}{315} = 0.033 \text{ inch} \qquad (3)$$

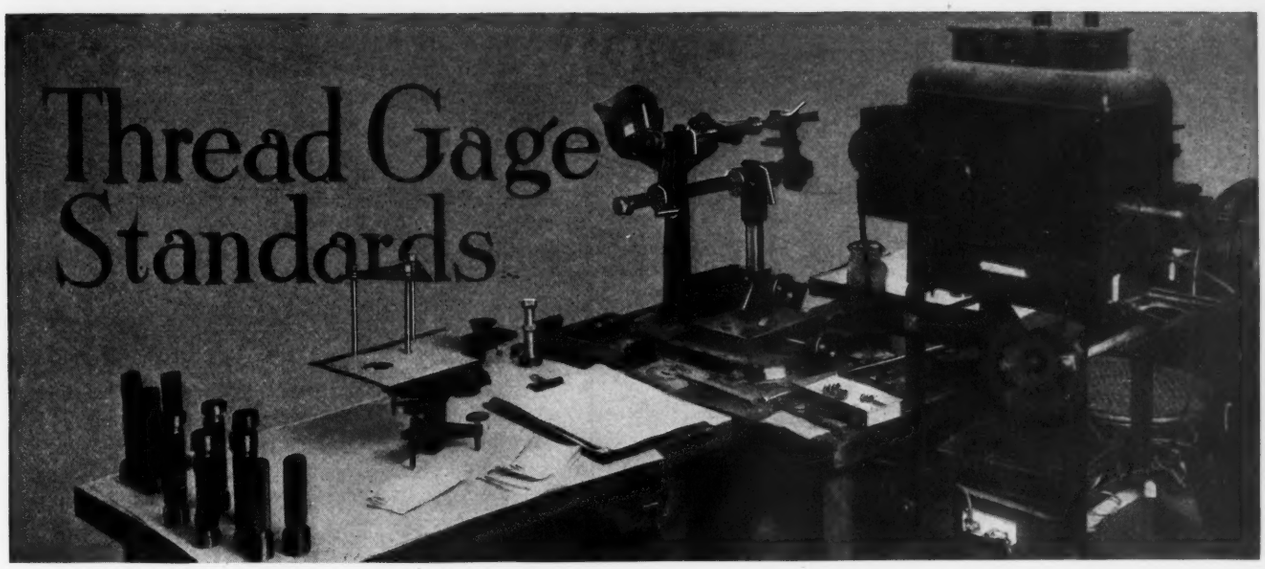
$$V = 0.500 - 0.033 = 0.467 \text{ inch} \qquad (4)$$

$$\text{Cos } a = \frac{0.467 \times 0.96593}{0.500} = 0.9021 \qquad (5)$$

Therefore angle $a = 25$ degrees 34 minutes.

* * *

It is reported that successful trial flights have been made in Germany by a great Zeppelin driven by seven motors and capable of carrying 100 passengers, in addition to the crew. According to the *Scientific American*, there is information from Berlin to the effect that this airship is the first of a regular airship service to be conducted by a German company connecting Stockholm and Copenhagen with Berlin, the major object being the assumption of a leading position in Scandinavian affairs in competition with British and French rivals.



A Complete System for Thread Plug and Ring Gages

By J. E. COLLINS

THE system outlined in this article applies to U. S. standard threads and may be modified to meet the needs of the manufacturer. For example, the snap gages and plain ring gages used in connection with the thread ring gages may be, in some cases, entirely dispensed with. The system starts in the drafting-room where the part or machine drawings are detailed and where the thread tolerances must be standardized. The method to be followed is worked out in a simple manner, and will be outlined in this article.

The work shown at *A*, Fig. 1, is taken as an example, and a complete set of the gaging equipment for both the external and internal threads is detailed in this illustration. The following gages are required for the male thread: One "Go" and one "Not Go" thread ring gage for gaging the pitch diameter; one snap gage, for gaging the minimum outside diameter; one ring gage for gaging the maximum outside diameter; one check for the thread ring gages; one plug gage for the core diameter. The two thread ring gages for the pitch diameter are shown at *C*, Fig. 1, while their checks are shown at *B*. In this connection, it should be stated that it is necessary to make checks for all thread ring gages, not only to use as a check for wear but for use in manufacturing the ring itself. All checks are made to the same dimensions as the gage itself. As there must be a "Go" and a "Not Go" gage for the pitch diameters of the work, these maximum and minimum pitch diameters are taken as the basic measurement for all thread gages. The maximum and minimum pitch diameters of the male thread on the work shown at *A* are 2.4680 and 2.4620 inches, respectively; therefore, the gages must be given these pitch diameter dimensions. The tolerance for these basic dimensions is taken from Table 1, which gives the tolerances on master thread gages. As the number of threads per inch in the

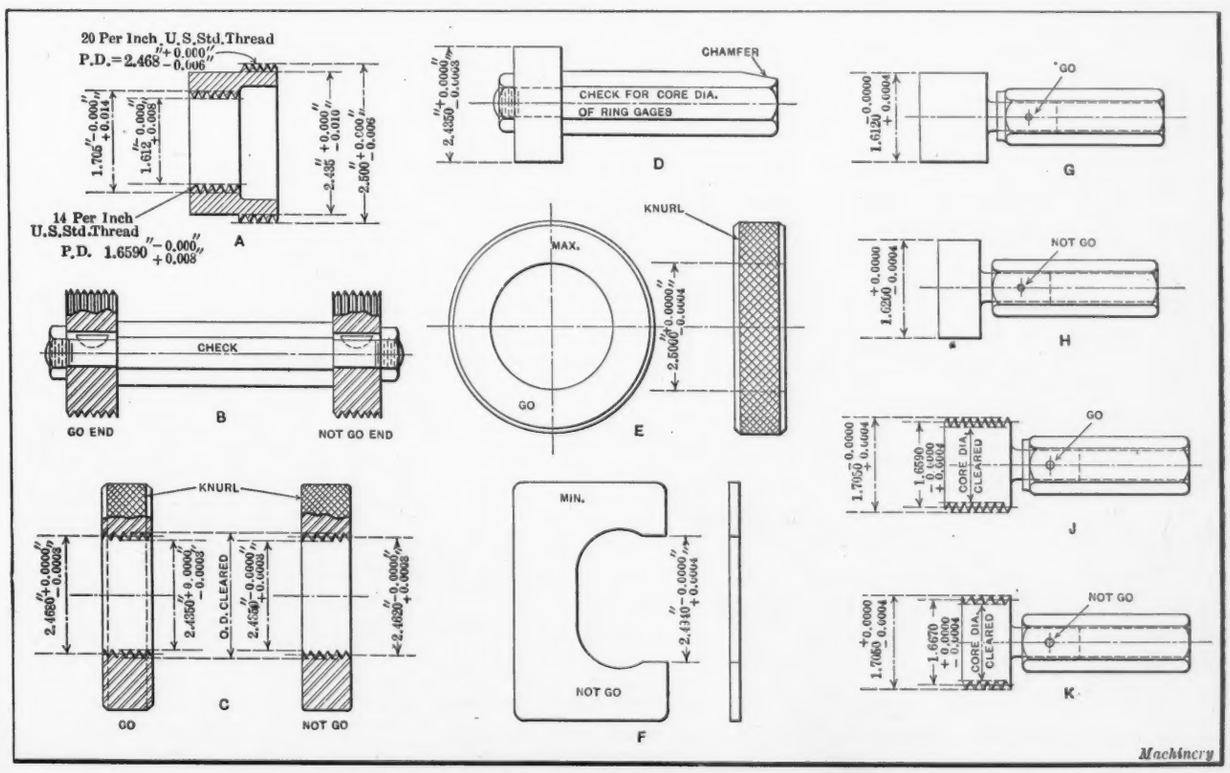


Fig. 1. Complete Set of Gages for External and Internal Threads on Work A

TABLE 1. TOLERANCES ON MASTER THREAD GAGES

Number of Threads per Inch	Allowable Variation in Lead in Effective Length of Gage, Inch	Allowable Variation in One-half Included Angle of Thread	Allowable Tolerance on Diameters of "Go" Male and "Not Go" Female Thread Gages, Inch	Allowable Tolerance on Diameters of "Not Go" Male and "Go" Female Thread Gages, Inch
4 to 6	±0.0005	±0° to 5′	—0.0000 +0.0006	+0.0000 —0.0006
7 to 10	±0.0004	±0° to 5′	—0.0000 +0.0004	+0.0000 —0.0004
11 to 18	±0.0003	±0° to 10′	—0.0000 +0.0004	+0.0000 —0.0004
20 to 28	±0.0002	±0° to 15′	—0.0000 +0.0003	+0.0000 —0.0003
30 to 40	±0.0002	±0° to 20′	—0.0000 +0.0002	+0.0000 —0.0002
44 to 56	±0.0002	±0° to 30′	—0.0000 +0.0002	+0.0000 —0.0002
64 to 80	±0.0002	±0° to 30′	—0.0000 +0.0002	+0.0000 —0.0002

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example is 20, the tolerance for the diameters will be found in the space opposite the notation 20 to 28. This tolerance for the "Go" female gage is $\begin{matrix}+0.0000\\-0.0003\end{matrix}$ and for the "Not Go" female gage, $\begin{matrix}-0.0000\\+0.0003\end{matrix}$.

The next dimension desired for the ring gages is the core diameter. This dimension is given on the work itself as 2.435 inches, which is the outside diameter minus twice the depth of the thread. The core diameter of ring gages is the same for both "Go" and "Not Go" gages, but the tolerances differ; the latter are taken from the same column in Table 1 as the pitch diameter tolerances, and are applied in the same manner. The outside diameter of the thread in the gages clears the part to be gaged, and therefore no dimensions are necessary. It will be noted that the number of threads per inch is the governing factor for determining all tolerances.

The core diameter check for both ring gages is shown at *D* in the illustration. As both the "Go" and "Not Go" gages have the same basic core diameter dimension, 2.4350 inches, one check is sufficient for checking them. Accordingly, the "Go" gage dimension 2.4350 $\begin{matrix}+0.0000\\-0.0003\end{matrix}$ is used for the check diameter, as this is the smaller diameter of the rings on account of the minus 0.0003 tolerance. At *E* is shown the plain ring gage required for gaging the maximum outside diameter of the thread. This dimension is 2.5000 inches, and the tolerance $\begin{matrix}+0.0000\\-0.0004\end{matrix}$ is taken from Table 4 in the article "Snap, Plug, and Ring Gages," published in the November number of MACHINERY, the same as for standard tabulated rings. The view at *F* represents the snap gage required for the minimum outside diameter of the thread. The minimum outside diameter dimension equals 2.500 minus 0.006 or 2.4940 inches, and the tolerance $\begin{matrix}-0.0000\\+0.0004\end{matrix}$ is taken from the same table that was used to find the tolerance for the plain ring gage *E*.

The following gages are required for gaging the female thread on the work *A*: One plain "Go" and one "Not Go" plug gage for gaging the core diameter; one "Go" and one "Not Go" thread plug gage for gaging the pitch diameter. The thread plug gages are shown at *J* and *K*, the plain plug gages being shown at *G* and *H*. The dimensions for these gages are calculated in the same manner as the thread ring gage dimensions. The pitch diameter of the work is 1.659 $\begin{matrix}-0.000\\+0.008\end{matrix}$ and as *K* is the "Not Go" or maximum gage, the tolerance allowed on the work is added to the pitch diameter, making it 1.6670 inches. By referring to Table 1, the tolerance for 14 threads per inch is found to be $\begin{matrix}+0.0000\\-0.0004\end{matrix}$ on the diameter of a "Not Go" male thread gage; therefore the pitch diameter of *K* is 1.6670 $\begin{matrix}+0.0000\\-0.0004\end{matrix}$ inches. The outside diameter dimension on thread plug gages never varies from the basic figure given on the work itself, except the tolerances on the gage proper. The work shown in the illustration gives this dimension as 1.7050 inches and the tolerance on the gage $\begin{matrix}+0.0000\\-0.0004\end{matrix}$ which is taken from Table 1. As the core diameter on male thread gages is always cleared, no dimensions are necessary.

The gage shown at *J* is the "Go" or minimum gage for the internal thread. The outside diameter, or 1.7050 inches, is the basic dimension of the work, and the pitch diameter is the minimum pitch diameter of the work, or 1.6590 inches. Referring to Table 1 for "Go" male thread gages the tolerance is found to be $\begin{matrix}-0.0000\\+0.0004\end{matrix}$. The core diameter is cleared, the same as for the "Not Go" gage *K*.

A "Go" and a "Not Go" gage are required for the core diameter of internal thread work in order to hold the work within the limits allowed. The "Go" gage shown at *G* is a standard plug gage made to the minimum diameter allowed on the work, which is 1.612 inches. The tolerance on this plain gage is also taken from Table 4, in the article published in the November number, and as the tolerance on the work is 0.008 inch, the gage tolerance will be found opposite the work tolerance 0.006 to 0.010, and in Table 1 in the column for "Go" male and "Not Go" female gages. This value is $\begin{matrix}-0.0000\\+0.0004\end{matrix}$; therefore, the gage dimension is 1.6120 $\begin{matrix}-0.0000\\+0.0004\end{matrix}$ inches. The "Not Go" gage illustrated at *H* is a maximum gage which measures the largest internal diameter on the work, which is 1.612 inches plus the tolerance 0.008,

TABLE 2. TOLERANCES ON INSPECTION THREAD GAGES

Number of Threads per Inch	Allowable Variation in Lead in Effective Length of Gage, Inch	Allowable Variation in One-half Included Angle of Thread	Allowable Tolerance on Diameters of "Go" Male and "Not Go" Female Thread Gages, Inch	Allowable Tolerance on Diameters of "Not Go" Male and "Go" Female Thread Gages, Inch
4 to 6	±0.0006	±0° to 5′	+0.0006 +0.0015	—0.0006 —0.0015
7 to 10	±0.0005	±0° to 10′	+0.0004 +0.0010	—0.0004 —0.0010
11 to 18	±0.0004	±0° to 15′	+0.0004 +0.0008	—0.0004 —0.0008
20 to 28	±0.0003	±0° to 20′	+0.0003 +0.0006	—0.0003 —0.0006
30 to 40	±0.0002	±0° to 30′	+0.0002 +0.0005	—0.0002 —0.0005
44 to 56	±0.0002	±0° to 45′	+0.0002 +0.0004	—0.0002 —0.0004
64 to 80	±0.0002	±0° to 45′	+0.0002 +0.0004	—0.0002 —0.0004

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or 1.620 inches. The tolerance for the gage proper is $\begin{matrix}+0.0000\\-0.0004\end{matrix}$ as taken from Table 1; therefore the gage dimension is $1.620\ \begin{matrix}+0.0000\\-0.0004\end{matrix}$ inches.

The manufacturing tolerances allowed on threaded parts are given in Table 4 for loose, medium, and close fits, and may be used in connection with the diagram, Fig. 2. The example taken to illustrate the gage tolerances is intended for a medium fit; therefore the tolerances on the outside and pitch diameters of the male thread (see *A* Fig. 1) are, $\begin{matrix}+0.000\\-0.006\end{matrix}$ which will be found in Table 4, for medium fits, opposite the notation which corresponds to the number of threads in the screw, which in this case would be 20-28. In like manner, the core diameter tolerance is found to be $\begin{matrix}+0.000\\-0.010\end{matrix}$. The same procedure is followed in determining the tolerance on internal threads such as in nuts or tapped holes.

Neutral Space and Direction of Tolerances

Fig. 2 illustrates the condition of the neutral space found when the female part, or nut, has its minimum dimension, and when the male part, or screw, has its maximum dimension. The maximum screw is the basic size from which all dimensions are computed. All tolerances applied to the diameters on the screw are minus, and all those applied to the diameters on the nut are plus. The view at the right in Fig. 3 shows the method of dimensioning and the application of tolerances of a screw as they should be carried out on component drawings. The tolerances given for the screw are taken from the table of tolerances for medium fits (Table 4). At the left is shown the dimensions and tolerances of a nut which is the mate of the screw shown at the right. The minimum nut diameters are found by adding the amount of the neutral space (see Table 4) to the maximum or basic screw diameters.

The question of the class of fit, that is, whether a close, medium, or loose fit is to be chosen, depends upon the function of the parts. Consideration should be given to the accuracy required, and the particular class of tolerance should be chosen that best suits the conditions involved. Attention is called to the fact that the tolerances specified in the various classes of fits (Table 4) for the core diameter of a screw and for the outside diameter of a nut differ from those specified for the other diameters. This condition results in the possible production of a thread, the flat of which at the root may be less than that of a true U. S. standard thread (see Fig. 2). This condition, however, is permissible, as it allows additional wear on the cutting tools and thus expedites manufacture. The tolerances for the core diameters of screws and for the outside diameters of nuts are so proportioned as to allow taps and threading tools to be made with a flat which is but 75 per cent of the standard flat. In no case will these tolerances result in a thread which is cleared more than midway between the flat of a true U. S. form and a sharp vee.

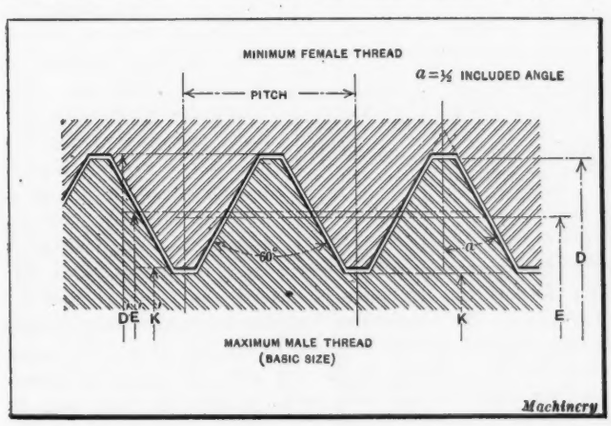

Fig. 2. Diagram showing Neutral Space between Maximum Screw and Minimum Nut

TABLE 3. TOLERANCES ON WORKING THREAD GAGES

Number of Threads per Inch	Allowable Variation in Lead in Effective Length of Gage, Inch	Allowable Variation in One-half Included Angle of Thread	Allowable Tolerance on Diameters of "Go" Male and "Not Go" Female Thread Gages, Inch	Allowable Tolerance on Diameters of "Not Go" Male and "Go" Female Thread Gages, Inch
4 to 6	±0.0006	±0° to 5′	+0.0015 +0.0025	—0.0015 —0.0025
7 to 10	±0.0005	±0° to 10′	+0.0010 +0.0020	—0.0010 —0.0020
11 to 18	±0.0004	±0° to 15′	+0.0008 +0.0015	—0.0008 —0.0015
20 to 28	±0.0003	±0° to 20′	+0.0006 +0.0012	—0.0006 —0.0012
30 to 40	±0.0002	±0° to 30′	+0.0005 +0.0010	—0.0005 —0.0010
44 to 56	±0.0002	±0° to 45′	+0.0004 +0.0006	—0.0004 —0.0006
64 to 80	±0.0002	±0° to 45′	+0.0004 +0.0006	—0.0004 —0.0006

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In order to prevent errors in the construction of gages and threading tools, a note should appear conspicuously on all part drawings, stating that the threads do not conform at the root to the U. S. form, owing to the additional tolerance allowance. It might be stated here that the tolerances on the outside and the core diameters could be greater than those given in the table on gage tolerances without making the threads dangerously weak, but the pitch diameter must be held as close as possible, as that is where a good fit is required.

Standard Thread Plugs

At *A*, Fig. 4, is shown a general design of thread plug gages used for gaging work up to and including 1 inch in diameter. For this size, a double-end gage is used on both thread and plain plug gages for measuring the core diameter. The gage is furnished with a standard hexagon handle made after the design shown in the illustration accompanying Table 2, in the article in the November number of MACHINERY. A single-ended thread plug gage is shown at *B* for use on work from 1 to 2 inches in diameter, inclusive. These plugs are too large to be made double-ended. A standard handle is used, having a bead turned at the plug end as shown, for identification purposes when used as a "Go" gage.

The plug gage at *C* is single-ended and of the built-up type. This type is used for gaging threads over 2 inches in diameter. The handle is beveled to an angle of 15 degrees on one end for identification purposes when used as a "Go" gage. At *D* is shown the detail of a standard handle for checks that are used for ring gages which gage work over 2 inches in diameter. Checks may be made double-ended, as the rings are intended to be kept together, and they should be screwed on the checks when not in actual use. When gaging work under 2 inches in diameter, the standard plain plug gage handles may be used for the checks. The same specifications that were given in the November number for plain plug gages apply to thread plug gages, but in addition the following information should be observed:

"Not Go" Gages for Pitch Diameter Only—All "Not Go" thread plug gages should be made as gages for effective or pitch diameter only. This necessitates the removal of the crest and root of the thread so that the dimensions of the outside and core diameters are less than those specified for

the "Go" gage. It may be stated that these dimensions of a "Not Go" thread plug gage should be the same as those specified for the corresponding diameters of the "Go" gage, with the exception that the tolerance to be applied on these diameters of the "Not Go" gage will be in a direction opposite to that of the "Go" gage. (See *J* and *K*, Fig. 1.)

TABLE 4. TOTAL MANUFACTURING TOLERANCES ON UNITED STATES STANDARD THREADS

	No. of Threads Per Inch	TOLERANCES ON SCREWS			Neutral Space Between Max. Screw and Min. Nut Inch	TOLERANCES ON NUTS		
		D Outside Dia. Inch	E Pitch Dia. Inch	K Core Dia. Inch		D′ Outside Dia. Inch	E′ Pitch Dia. Inch	K′ Core Dia. Inch
LOOSE FIT	4 to 6	+0.000 −0.030	+0.000 −0.030	+0.000 −0.045	0.008	−0.000 +0.045	−0.000 +0.030	−0.000 +0.030
	7 to 10	+0.000 −0.020	+0.000 −0.020	+0.000 −0.030	0.006	−0.000 +0.030	−0.000 +0.020	−0.000 +0.020
	11 to 18	+0.000 −0.012	+0.000 −0.012	+0.000 −0.018	0.005	−0.000 +0.018	−0.000 +0.012	−0.000 +0.012
	20 to 28	+0.000 −0.008	+0.000 −0.008	+0.000 −0.012	0.004	−0.000 +0.012	−0.000 +0.008	−0.000 +0.008
	30 to 40	+0.000 −0.006	+0.000 −0.006	+0.000 −0.008	0.003	−0.000 +0.008	−0.000 +0.006	−0.000 +0.006
	44 to 56	+0.000 −0.004	+0.000 −0.004	+0.000 −0.006	0.002	−0.000 +0.006	−0.000 +0.004	−0.000 +0.004
	64 to 80	+0.000 −0.003	+0.000 −0.003	+0.000 −0.004	0.001	−0.000 +0.004	−0.000 +0.003	−0.000 +0.003
MEDIUM FIT	4 to 6	+0.000 −0.016	+0.000 −0.016	+0.000 −0.035	0.008	−0.000 +0.035	−0.000 +0.016	−0.000 +0.016
	7 to 10	+0.000 −0.012	+0.000 −0.012	+0.000 −0.022	0.006	−0.000 +0.022	−0.000 +0.012	−0.000 +0.012
	11 to 18	+0.000 −0.008	+0.000 −0.008	+0.000 −0.014	0.005	−0.000 +0.014	−0.000 +0.008	−0.000 +0.008
	20 to 28	+0.000 −0.006	+0.000 −0.006	+0.000 −0.010	0.004	−0.000 +0.010	−0.000 +0.006	−0.000 +0.006
	30 to 40	+0.000 −0.004	+0.000 −0.004	+0.000 −0.007	0.003	−0.000 +0.007	−0.000 +0.004	−0.000 +0.004
	44 to 56	+0.000 −0.003	+0.000 −0.003	+0.000 −0.005	0.002	−0.000 +0.005	−0.000 +0.003	−0.000 +0.003
	64 to 80	+0.000 −0.002	+0.000 −0.002	+0.000 −0.003	0.001	−0.000 +0.003	−0.000 +0.002	−0.000 +0.002
CLOSE FIT	4 to 6	+0.000 −0.008	+0.000 −0.008	+0.000 −0.025	0.008	−0.000 +0.025	−0.000 +0.008	−0.000 +0.008
	7 to 10	+0.000 −0.006	+0.000 −0.006	+0.000 −0.016	0.006	−0.000 +0.016	−0.000 +0.006	−0.000 +0.006
	11 to 18	+0.000 −0.005	+0.000 −0.005	+0.000 −0.010	0.005	−0.000 +0.010	−0.000 +0.005	−0.000 +0.005
	20 to 28	+0.000 −0.004	+0.000 −0.004	+0.000 −0.008	0.004	−0.000 +0.008	−0.000 +0.004	−0.000 +0.004
	30 to 40	+0.000 −0.003	+0.000 −0.003	+0.000 −0.006	0.003	−0.000 +0.006	−0.000 +0.003	−0.000 +0.003
	44 to 56	+0.000 −0.002	+0.000 −0.002	+0.000 −0.004	0.002	−0.000 +0.004	−0.000 +0.002	−0.000 +0.002
	64 to 80	+0.000 −0.0015	+0.000 −0.0015	+0.000 −0.003	0.001	−0.000 +0.003	−0.000 +0.0015	−0.000 +0.0015

Machinery

Clearing Core Diameter—On a thread plug gage the portion of the thread that is below the core diameter of a true U. S. standard form may be cleared to facilitate grinding and lapping. In no case, however, should the core diameter which results in the clearing be less than the core diameter of a thread plug gage having a sharp V-thread of the same pitch and effective diameter as those which are specified for the gage.

The specifications which were given in the November number of MACHINERY for plain ring gages apply also to thread ring gages, but in addition the following information should be observed:

"Not Go" Gages for Pitch Diameter Only—All "Not Go" thread ring gages should be made as gages for pitch diameter only. This necessitates the removal of the crest and root of the thread so that the dimensions of the core and outside diameters are greater than those specified for the "Go" gage. It may be stated that the dimensions of these diameters for a "Not Go" ring gage should be the same as those specified for corresponding diameters of the "Go" gage, with the exception that the tolerance to be applied on the core and outside diameters will be in a direction opposite to that on the "Go" gage. (See *C*, Fig 1.)

Clearing Outside Diameter—On a thread ring gage the portion of thread which is above the outside diameter of a true U. S. standard form may be cleared to allow clearance in grinding and lapping. In no case, however, should the full diameter which results from this clearing be greater than the full diameter of a ring gage having a sharp V-thread of the same pitch and effective diameter as those which are specified for the gage.

Application of Tolerances

The tolerances for thread gage diameters given in Tables 1, 2, and 3 are applied in such a manner that the tolerances permitted on the gages include part of the manufacturing tolerances allowed on the work. This insures that any work passed by the gages will be within the tolerance specified on the part drawing. The tolerances given also permit a gage that is not suitable for a master gage to be classified and used as an inspection or working gage. The application of the tolerances on the diameters of thread gages is exactly the same as that for plain gages. In connection with the tolerances for working thread gages, attention is called to the fact that if the tolerances given (especially those for lead and angle) are used, working gages which have been reduced by wear may be utilized as inspection gages.

The tolerances on lead are given in terms of an allowance for the effective length of the gage. This allowance depends

upon the number of threads per inch, as indicated in Tables 1, 2, and 3. For instance, a "Go" master thread gage is, say, 1.18 inches in effective length and has 12 threads per inch. The "Go" gage should be made 1.18 inches long, and the error in lead over two threads which are not further apart than 1.18 inches, should not, according to Table 1, exceed ±0.0003 inch. For the "Not Go" gage, the tolerances on lead will be the same as for the "Go" gage, with the exception that the effective length of the "Not Go" gage, or 1.18 inches, will be the actual length of the gage.

The tolerances on the included angle of thread gages, as given for the various pitches in Tables 1, 2, and 3, are on the basis of threads having straight sides. The equivalent deviations from the true thread form by such irregularities as concave sides, rounded crests and slight projections, should not exceed the tolerances allowed on the angle. The various elements of thread ring gages should be correct within the previously mentioned tolerances for thread gages. Thread ring gages may be standardized with reference to the fit on a plug gage that does not differ appreciably from the thread ring gage in its elements of lead and angle of thread.

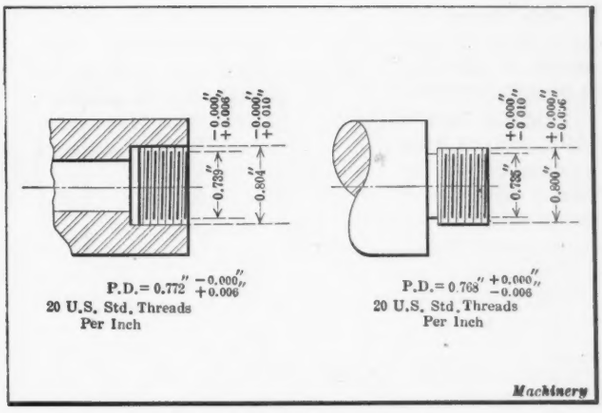


Fig. 3. Application of Neutral Space Dimensions to Thread Measurements

Measurement of Pitch Diameter of Thread Gages Using Three-wire Method

The various elements of thread plug gages should be correct within the variations allowed in the previous scale of tolerances when the measurements are made by reliable methods. In measuring the effective diameter of thread plug gages, the three-wire method of measurement in which the "best" size of wire is used, is well known and reliable. By the "best" size wire is meant the wire which touches at the mid-slope of the thread. For the U. S. standard form of screw threads the "best" sizes of wires for the various pitches are given in Table 5.

The set of three wires for use in measuring screw threads should each have the same diameter within 0.00005 inch. This common diameter, however, may vary from the "best" sizes as given in the table by as much as 0.001 inch, but preferably not more than 0.0005 inch. If there is any difference in diameter in the three wires, the two which are nearest the same size should be used on one side of the thread, and the mean value of the diameters of all three wires should be used in making the computations of the pitch diameter. The formula for use in computing the pitch diameter, where the "best" size of wire is used, is

$$PD = M + H - 3D$$

in which PD is the effective or pitch diameter, M the measurement over the wires, D the mean diameter of the wires, and H a variable value determined by Table 5.

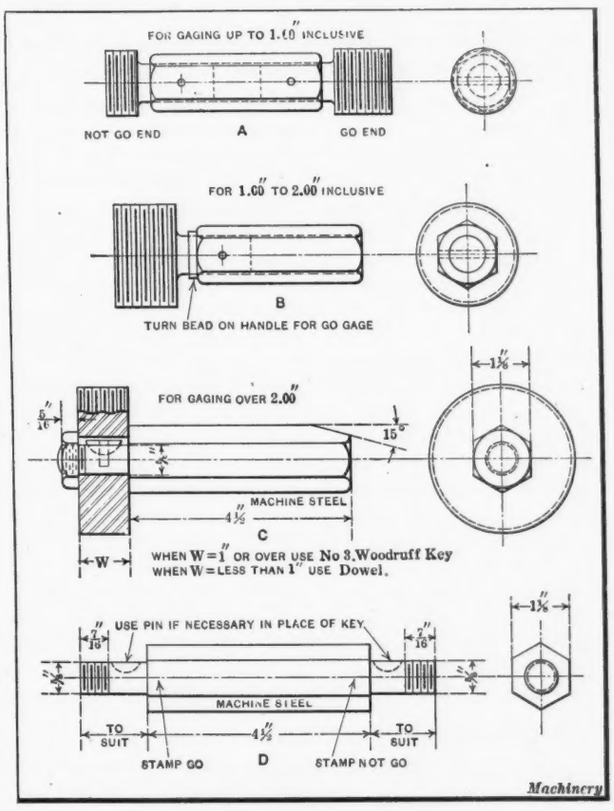


Fig. 4. Standard Thread Plugs

Effects of Heat-treatment

Thread gages have given more trouble to manufacturers, possibly, than any other type of gage, since a considerable understanding of detail is required in their manufacture. Most gages are held to a 0.0003-inch limit, including the lead, and when the shape of the thread is examined by projecting it on a screen by means of a projection lantern, the difficulties of manufacturing thread gages of any design become apparent. Experience with several brands of non-shrinking steel has shown that quenching after heating lengthens the lead at least from 0.0025 to 0.0035 inch. It is difficult to understand why a gage should lengthen instead of shrink, and no satisfactory explanation has ever been given of this condition, as far as the writer knows. The steel used, of course, has a great deal to do with what happens in hardening, and some steels have a tendency to lengthen.

Lapping

Four sizes of laps should be sufficient. In the case of large size gages, for instance 2 inches or more in diameter, 0.005 inch of metal should be left for lapping, although it is the practice of some concerns to leave less, but in such cases there is the possibility that, due to hardening, the gages will not "clean up" in finishing. Some gage manufacturers grind the threads, which is an efficient process, but requires a grinding wheel of the correct shape and one that will hold its shape. There should be no great difficulty in this respect, however, since there may be found on the market various types of wheels which will hold their cutting edge. The wheel should

TABLE 5. VALUES FOR COMPUTING PITCH DIAMETER WHEN USING THREE-WIRE METHOD

Thds. per Inch	Best Wire Diameter	H	Thds. per Inch	Best Wire Diameter	H
80	0.0072	0.01083	14	0.0412	0.06186
64	0.0090	0.01385	13	0.0444	0.06662
50	0.0116	0.01732	12	0.0481	0.07217
44	0.0131	0.01968	11	0.0525	0.07873
40	0.0144	0.02165	10	0.0577	0.08660
36	0.0160	0.02406	9	0.0642	0.09623
32	0.0180	0.02706	8	0.0722	0.10825
28	0.0206	0.03093	7	0.0825	0.12372
26	0.0222	0.03331	6	0.0962	0.14434
24	0.0241	0.03603	5½	0.1050	0.15750
22	0.0262	0.03936	5	0.1155	0.17321
20	0.0289	0.04330	4½	0.1283	0.19250
18	0.0321	0.04811	4	0.1443	0.21651
16	0.0361	0.05413			

Machinery

be wide enough and the fixture heavy enough to take care of possible vibration. A wheel ¼ inch in width and as large in diameter as the fixture will permit should be used, as the larger the diameter, the better the cutting edge of the wheel will hold.

Thread Gage Inspection Department Equipment

An outline of the equipment a thread gage inspection department should have to insure the highest possible grade of gages is given in the following: It should be equipped with (1) a pitch-measuring machine to read an error in lead of at least 0.0001 inch; (2) an appliance to take casts of ring screw gages, so arranged that the cast may be accurately set up in the pitch-measuring machine or in the projection apparatus; (3) a screw measuring machine to check the governing diameters of a punch screw gage to within an accuracy of 0.0001 inch, and an equipment of "best" diameter and maximum diameter wires and triangular pieces to be used in conjunction with the screw measuring machine; (4) thread micrometers, checked for accuracy, also for use in conjunction with the screw measuring machine; (5) ordinary micrometers for use in measuring outside diameters, and precision gage-blocks to insure the accuracy of the micrometers; and (6) a complete set of check plugs for the several diameters, pitch and form of thread in ring screw gages. The above equipment would be complete with a projection apparatus for observing the angle between the slopes of the thread, and the form of the entire thread.

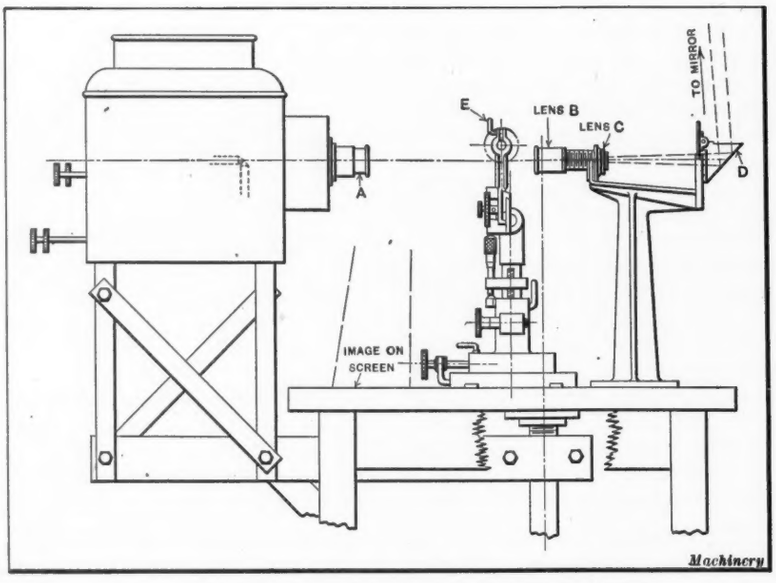


Fig. 5. Projection Lantern Apparatus used in inspecting Threads

Measurement of Screw Threads by the Shadow Projection Method

In principle, the use of the projection apparatus is as follows: The screw is placed in a parallel beam of light and an enlarged image of its shadow is obtained on a distant screen by means of a projecting lens. The screen is optically parallel with the axis of the screw and perpendicular to the axis of the projecting lens. The parallel beam of light must pass through the thread of the screw at the helix angle, so that the shadow cast will be that of a section made through the axial plane of the screw.

Referring to Fig. 5, which shows the assembly of the projection apparatus, the operation is as follows: The screw to be examined is supported on the stand *E* and occupies the position indicated by the dot-and-dash circle. If a male gage is to be measured, it is supported between the centers, and after the screw is fixed, the lamp is turned about the axis of its support, until it is in a proper position to provide that parallel rays of light from the lens *A* pass through the helix angle of the thread. This adjustment is made when the thread is slightly out of focus, as when the fringe pattern formed about the image of the screw is symmetrical, the correct position of the lantern has been secured. The position of the screw is then changed until the image on the screen has a sharp outline. The angle of thread is determined from the shadow by means of a suitable protractor, templet, or other device. The thread is also examined for imperfections in lapping, and in case it is desired, an exposure may be made with bromide paper, to record such details. In the apparatus shown, the projection is directed upward by the prism *D* to a mirror which is supported about 10 feet above the prism from which it is directed by the mirror vertically downward to the top of a table which forms the screen. The use of the prism and the mirror may be dispensed with, and the projection made directly on a vertical screen at the proper distance from the lens.

Examination of the thread form of ring gages is made by

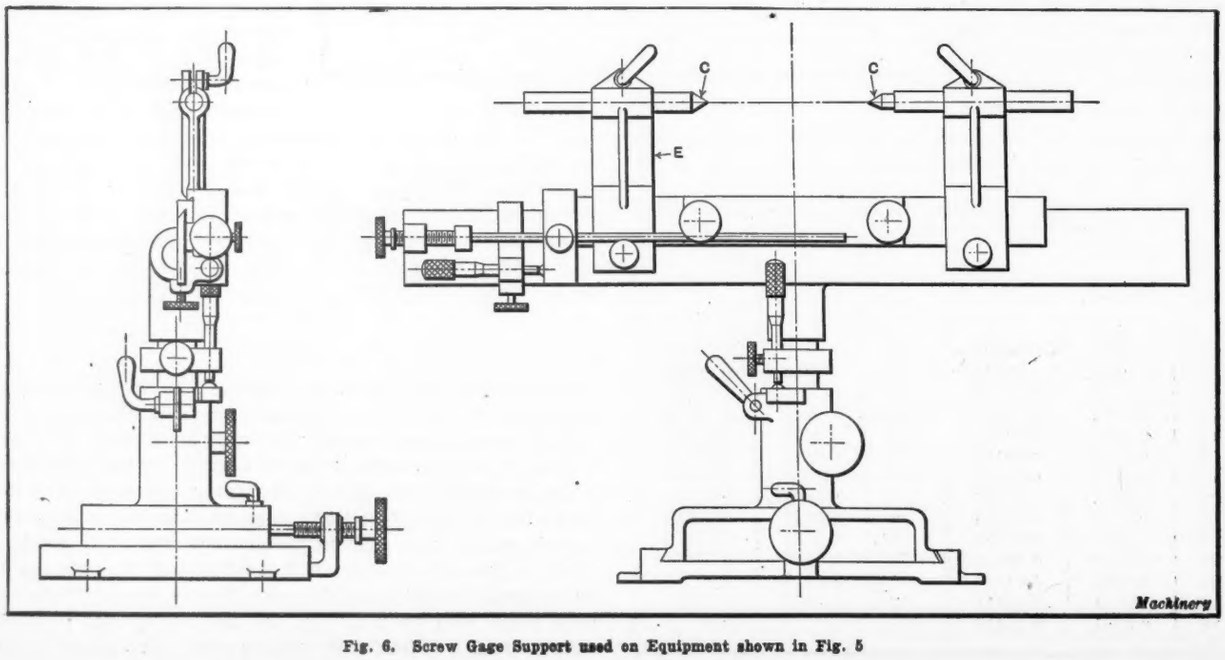


Fig. 6. Screw Gage Support used on Equipment shown in Fig. 5

making a cast of a segment of the thread. A mixture of about 1 part lampblack or graphite, and 18 parts sulphur, is heated to a fluid state and then poured into the lower side of a ring gage, which is held in a vertical position in a vise, and provided with suitable means of preventing the melted mixture from escaping. The threads are carefully cleaned so that the cast will represent the actual shape of the thread. Casts should not be poured deeper than ⅜ inch, on account of distortion caused by unevenness in cooling—shallow casts of a size sufficient for handling being preferable. Great care should be taken to prevent heating the sulphur or graphite beyond the melting point, as when overheated it becomes thicker, and imperfect casts may result. Very small casts should be mounted on a small block of wood with a drop of glue. Casts change shape gradually, and all examinations should be completed within three hours after pouring. The casts are supported in the apparatus by removing the gage support centers *C*, Fig. 6, and changing their ends so that the butt of each is resting against the cast. The use of the prism and a mirror enables one operator to adjust the screw and lantern conveniently and at the same time to be able to observe the image at close range. A 2½-inch aperture right prism will be found of sufficient size, and a mirror having a diameter of about 8 inches will be amply large. It is necessary to secure a prism whose three faces are accurately flat within one wave length of light, which corresponds to about 0.00001 inch. The same degree of flatness is required in the mirror, and in addition the mirror must be silvered on the front. A screw gage support, the assembly of which is shown in Fig 6, will be found convenient, as it has adjustments for focusing the screw, as well as for raising and lowering it, and also for shifting the screw parallel to its axis in order that different threads may be examined.

* * *

POSSIBLE IMPROVEMENTS IN LUBRICATION METHODS

By CHARLES A. TRASK

Now that the war is over, machine tool manufacturers have an opportunity to look into such possible improvements in their product as their experience and the experience of their customers—the users of machine tools—during the past few years have shown to be desirable or necessary. Recent developments in manufacturing methods have imposed greater strains and more severe conditions on machine tools than those to which they were subjected in the past. This severe usage has served to disclose any weak points existing in their design.

Among the various improvements that have been shown to be possible, those relating to lubrication methods assume an important place. As an example may be mentioned the countershaft equipment frequently furnished with machine tools. Although this equipment does not form an integral part of the machine itself, many manufacturers supply complete countershafts, and in many instances these countershafts are provided with universally adjustable hangers, as well as with means for making ample adjustment of clutches, and proper means for retaining the lubricant, etc. Countershafts of this type are appreciated by the machine tool buyer. If, on the other hand, he receives a countershaft having non-adjustable hangers fitted with cast-iron boxes provided with only an oil-hole for lubrication, he may form an unfavorable opinion of the machine because of the countershaft, in spite of the fact that the machine tool itself may be of the highest quality.

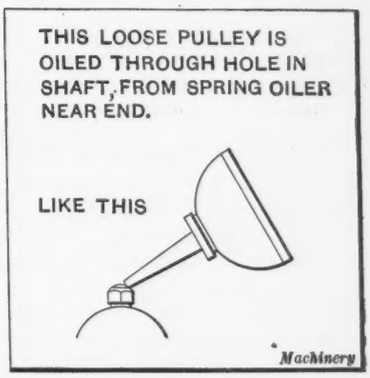


Fig. 2. Notice placed near Loose Pulley which shows Method of oiling

Countershafts, such as have been described, often cause considerable trouble due to improper lubrication and alignment. Loose pulleys which can be oiled only through a small oil-hole are almost certain to give trouble sooner or later, and it is not the man doing the oiling in the shop who should be blamed when the pulley sticks, but the designer who failed to make adequate provision for lubrication.

Improved Oiling System for Countershaft Boxes

Frequently, oiling devices are seen applied to loose pulleys, which, although quite elaborate in nature, fail to provide proper lubrication. A system which is furnished with a well-known make of machine tools has many excellent features, but due to a small point having been overlooked, the writer met with some difficulty in its use. These countershafts were supplied with cast-iron boxes in which oil cellars had been cast. In these cellars a small amount of cotton wick had been placed. There was not a sufficient amount of wicking to insure contact with the shaft, but the designer's intentions were all right. By removing the wick and pressing blocks of felt into the cellars with sufficient force to insure contact with the shaft, this difficulty was overcome, and in all probability no trouble will result from improper lubrication of the shaft boxes for several years, at least.

The loose pulley furnished with this equipment was provided with a pipe which screwed into the hub and extended through the rim. At the outer end, the tube, or pipe, was tapped and provided with a threaded plug intended to be removed with a screwdriver. The bore of the pulley was grooved for almost its entire length, the groove being ½ inch wide by ¼ inch deep. The oil-pipe connected directly with the oil-groove. The pipe and the groove would contain enough oil to lubricate the pulley for months, provided it could be retained and kept in contact with the shaft at all times; but in designing this oiling device the effect of centrifugal force had not been taken into consideration. As the loose pulley was intended to run at 450 revolutions per minute, the centrifugal force proved sufficient to throw the oil away from the shaft so that only at the noon and night shut-downs were the contents of the pipe allowed to come into contact with the shaft, shortly before the pulley came to rest. If the oil-pipe happened to be above the horizontal position when the pulley stopped, the oil supply would diminish rapidly due to leakage between the shaft and the pulley. If the oil-pipe came to rest below the horizontal position it would retain all the oil and as a result no oil would be likely to reach the shaft until the next shut-down. Then, too, unless the screw plug were properly seated, the oil would leak.

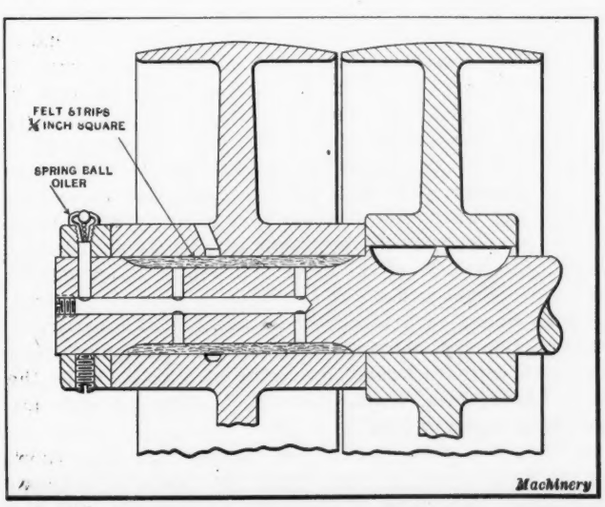


Fig. 1. Diagram showing Improved Oiling System for Loose Pulleys

It should be noted that the firm which furnishes the machine and the equipment seldom hears of these troubles. In cases like that cited, the machine builders could easily and inexpensively make the required improvements if the users of machine tools would inform the makers of such troubles.

Improved Oiling System for Loose Pulleys

A method of dealing with loose pulley trouble which has been found quite satisfactory is illustrated in Fig. 1. The writer has used this method of lubrication for many years on pulleys that were in constant operation. These pulleys fit as well today as they did when fitted up several years ago. When the loose pulley is close to the end of the shaft, a spring ball oiler is arranged in the cellar as shown, but when the pulley is so far from the end of the shaft that a very long hole would be required, a groove ¼ by 3/16 inch is cut all around the shaft under the oil-hole in the pulley. This permits both strips of felt to be thoroughly saturated at each application of oil. When the spring ball oiler is used, the notice shown in Fig. 2 is placed on a board and nailed up where the oiler will be sure to see it when he climbs up to oil the bearing.

Improved Oiling System for Spindle of Special-purpose Lathe

Some years ago several lathes were purchased from a firm with the understanding that the machines were to be operated at a higher speed than was common practice. These machines were finally delivered and they bore evidence of having been designed by an experienced and practical mind. The ends of the carriage where they came in contact with the ways were fitted with felt wipers and spring ball oilers; no back-gears were furnished or required. The cone ran loose on the spindle in the usual way, the spindle being picked up by a friction clutch operated by a hand-lever, and stopped by a brake operated by the same lever when the cone clutch was released; thus the cone rotated all day without stopping. Although liberally oiled through a screw plugged pipe, the cone stuck to the spindle three times during the first week it was in operation. The spindle was taken out each time, the bronze bushing scraped, and the lathe reassembled. The bore of the cone was about 13 inches long, and was bushed at each end with a bronze bushing about 5/16 inch thick and 4 inches long; thus the space for oil was about 5 inches long and 5/16 inch deep all around the spindle. This space held a large amount of oil, but at 700 revolutions per minute the oil held there was of no benefit; it is the writer's opinion that the arrangement would have been equally troublesome if the machine had been operated at only 250 revolutions per minute.

The trouble was remedied, however, by removing the bushings and drilling ten or a dozen ⅜-inch holes through each bushing. On the outside of the bushing helical grooves were cut running from each hole to the inside end of each bushing—right-hand helixes on the left-hand bushing and left-hand helixes on the right-hand bushing. Felt plugs, ⅜ inch in diameter and slightly over 5/16 inch long, were inserted in the holes before the bushings were replaced. This arrangement completely eliminated all further trouble, as the felt plugs were constantly saturated with oil and always in contact with the spindle. The same changes were made in the other lathes before putting them in service, and they have all operated satisfactorily.

* * *

INTERNATIONAL EXPOSITION OF INDUSTRIES

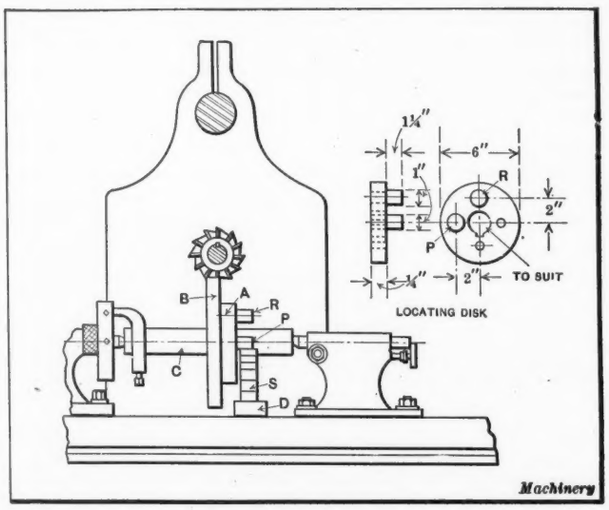
The management of the permanent exposition at the Grand Central Palace, New York City, announces that the organization of foreign exhibits has begun to assume tangible form. Contracts have been made for space for a permanent exposition of Swedish products, arrangements are pending for a Norwegian government exhibit, and negotiations with other countries are progressing. Two floors are given over to the exhibition of machinery of various classes. Farm tractors, trailers and agricultural machinery will occupy large space.

DIVIDING A DISK INTO EQUAL PARTS

By KURT MANRODT

The following method for dividing a disk into a given number of equal parts is mathematically correct. The work is performed on a milling machine, using an index-head and a locating disk which is made to suitable dimensions and to the design shown in the illustration. The locating disk should be accurately made, and the two plugs *P* and *R* should be precisely the same distance from the center of the disk and exactly 90 degrees apart.

In the example chosen for illustrating this method, it is required to cut thirteen notches in the circumference of disk *B*. This disk is clamped by suitable means to the locating disk *A*, both being concentric with the arbor *C*. The locating disk is so placed for the first cut that the center of plug *R* lies in the vertical center line of the arbor, which brings the center of plug *P* into the horizontal center line of the arbor, and, of course, parallel with the milling machine table. This is accomplished by placing a parallel block *D* on the table and using the proper gage-blocks *S* between the parallel block and plug *P*, to bring the indicating



Dividing the Periphery of a Disk into Equal Spaces

disk into the position mentioned. If the distance from the table to the horizontal center line is assumed to be 5 inches, and the thickness of the block *D*, 1 inch, then as *P* is 1 inch in diameter, the height of the gage-blocks is 3½ inches.

After the first notch has been cut with the disk in this position, the work must be revolved 1/13 of the circumference, or 27 degrees 41 minutes 32 4/13 seconds. This will result in dropping the position of plug *P* a distance equal to 2 × sin 27 degrees 41 minutes 32 4/13 seconds, or 0.9295 inch. This, then, represents the amount that must be taken from the 3½-inch stack of size blocks which leaves the height of the stack under plug *P*, 2.5705 inches. The index-head is then turned until this plug is pressed hard against the gage-blocks. The second notch is cut with the disk in this position, and the remaining cuts are spaced in practically the same manner, except that plug *P* is not used in every instance. As soon as the disk has been revolved more than 45 degrees, plug *R* is used to locate the succeeding notches, and when this plug has arrived at an angle of 45 degrees or more with the horizontal, the blocks are changed to the opposite side of the arbor and plug *P* is again used until it passes beyond the 45-degree angle from the vertical, at which time plug *R* is employed again. In this particular instance, the first, second, sixth, seventh, eight, ninth, and thirteenth cuts are located by means of plug *P;* while the third, fourth, fifth, tenth, eleventh, and twelfth cuts are located by means of plug *R*.

In using this method, it is best to prepare a table showing the plug to use for each notch, the height of the size-block stacks (exclusive of the parallel block *D*), and the angles corresponding to each notch.

Tool Salvage Department

Organization, Routine, and System of a Tool Salvage Department in a Modern Plant

By C. B. COLE, Chief Tool Inspector, Wright-Martin Aircraft Corporation, Long Island City, N. Y.

THE tool salvage department in manufacturing concerns is a comparatively new institution. Lately, however, many manufacturing concerns, and railroad and steamship companies have begun to realize the amount of tools, material, etc., that can be salvaged, thereby saving considerable expense and time. In modern manufacturing plants, large amounts of raw material, tools, fixtures, jigs, and gages can be salvaged and, with small cost, repaired to give further service by the adoption of a system such as here described.

The Tool Salvage Clerk

The man in charge of a tool salvage department should be a man who is thoroughly conversant with the tools, and also with the products that are being handled in the factory. Tools that are worn, broken, or otherwise damaged, can thus be passed upon as to their further serviceability. Tools that are rejected in the tool inspection department should be sent into the tool salvage department for final disposition.

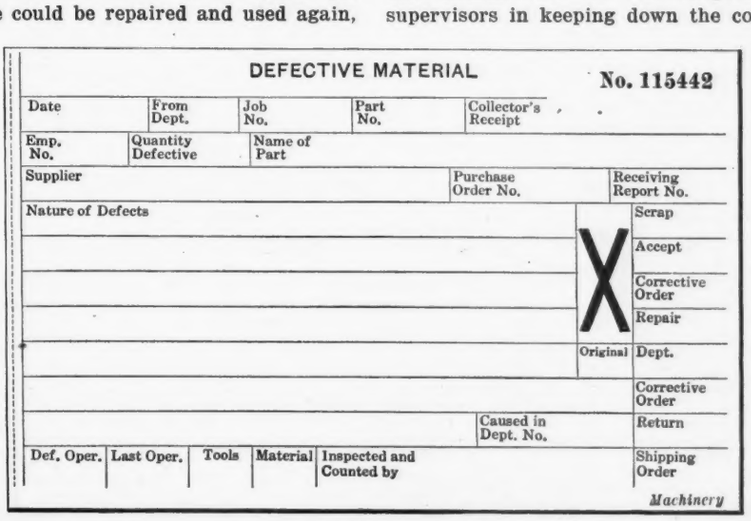
The tool salvage man should have as much assistance as possible from the management of the factory in order to enable him to dispose of the tools properly. A tool salvage committee should be organized to cooperate with the salvage clerk. This committee should consist of at least three members, one from the tool design department, one from the tool-room, and one from the production department. A large saving in time and in the cost of replacing tools will be gained from a properly operated tool salvage department. All tools, jigs, fixtures, gages, etc., that are received in the tool salvage department from various other departments should be properly tagged to show the department, the foreman's name, and the purpose for which the part is used, so that these various parts can be properly disposed of by the tool salvage man.

Functions of the Salvage Department

The tool salvage man should first consider whether the tools received for salvage could be repaired and used again, or whether it would be cheaper to scrap them outright. In connection with the tool salvage department, two storage rooms should be established, one for active and one for obsolete tools, the purpose of the latter room being to take care of tools whose usefulness has been destroyed through changes in design, or tools that have been altered. All tools, etc., sent to either of these store-rooms should have the signature of the tool salvage clerk on the tag and any other data that it might be necessary for the tool salvage man to refer to.

It has been shown by experience in large plants that departmental foremen have often become prejudiced against a certain type of tool and have ordered that it be scrapped. The tool salvage man, nevertheless, may be able to offset this condition by proving the usefulness of the tool. Sometimes the blueprints specify that a tool should be made to unnecessarily close limits. If the tool inspector finds that tools are not up to the blueprint specifications, he rejects them, although the close tolerances specified may not be necessary. The tool salvage man, being thoroughly familiar with the function of all tools in the shop, would often decide to pass such tools without having any alteration or corrections made on them. On the other hand, if the blueprint should not show close limits on classes of tools such as gages, the tool inspector might decide to pass such tools without knowing the circumstances under which they were to be used, and poor production would be the result. The tool salvage department acts as a check against any occurrence of this kind.

In many large tool-rooms, standard, temporary, and semi-finished tools are allowed to accumulate, as well as pieces of high-speed steel and tool steel. These are often permitted to gather on or under the benches until they have been forgotten, finally becoming classed as junk and sold as such, at a considerable loss to the factory. In a modern plant, however, such tools and material are sorted and kept in a place provided for them, until they are properly disposed of by the tool salvage department. It has often been discovered, after a little careful consideration, that such tools and material can be used to advantage. This method has saved considerable expense to the companies that have adopted it. The advice and opinion of a tool salvage man who is thoroughly familiar with his duties has often proved of invaluable assistance to the tool designer and to the production supervisors in keeping down the cost of production.


DEFECTIVE MATERIAL No. 115442

Date	From Dept.	Job No.	Part No.	Collector's Receipt
Emp. No.	Quantity Defective	Name of Part		
Supplier			Purchase Order No.	Receiving Report No.

Nature of Defects		
	X	Scrap
		Accept
		Corrective Order
		Repair
	Original	Dept.
		Corrective Order
	Caused in Dept. No.	Return

Def. Oper.	Last Oper.	Tools	Material	Inspected and Counted by	Shipping Order

Machinery

Fig. 1. Defective Material Slip

Instruction and Routine under which a Modern Salvage Department is Operated

The following is an outline of the instruction and routine under which a salvage department of a certain large plant operates, and may serve, with proper modifications and changes, to meet the needs of other large plants. Many of the tools used in this particular plant are furnished by outside sources, that is, by venders. The tool salvage department consists of

a chief salvage clerk and any other necessary help, such as clerks and stenographers. This department is not a storage crib, and all material sent there for final disposition is disposed of as promptly as possible. Tools that are to be returned to the vender, are not held longer than forty-eight hours without an inquiry being made as to the delay in delivery. Tools that are received in the salvaging department are disposed of by being returned to the vender, repaired or corrected in the tool-room, or sent to the tool distribution crib, the obsolete tool-crib, the tool storage, or to scrap.

2439—7500—11—20—18

TOOL INSPECTION RECORD

TOOL NUMBER | Tool Name | ORDER NUMBER

Part No. Part Name

RESULT OF INSPECTION

	DATE	Passed	Rejected	Inspected by	REASON FOR REJECTION
FIRST INSPECTION					
SECOND INSPECTION					
FINAL INSPECTION					

Delivered to By Date

Remarks:

Machinery

Fig. 2. Tool Inspection Record

The chief salvage clerk reports directly to the chief tool inspector. The former acts on the final disposition of all tools, both durable and non-durable, that have been rejected by the tool inspection department. When a tool that has been rejected by the tool inspection department is accepted by the salvage man, notation is made on the defective material tag, Fig. 1, a duplicate copy of which is filled out, detached, and filed in the tool salvage crib, and all other tags or papers are forwarded to the tool distribution man.

The salvage clerk also finally disposes of all semi-finished tools received from outside sources, as well as special tools that have been made or used by the vender on fabricated parts. All tools received from outside sources, if rejected by the tool inspection department, are sent to the tool salvage department, accompanied by the properly filled out defective material tag. All necessary information regarding the reason for rejection is filled in on the tool inspection record slip, Fig. 2, which together with the receiving slip and other information that may be of value, is sent to the salvage clerk to guide him in disposing of the tools. If several tools are received from an outside vender, and some of them are rejected by the tool inspection, the entire quantity, both passed and rejected, is sent to the chief salvage clerk who decides as to the disposition of the rejected tools.

When an entire lot or shipment of tools received from outside sources has been rejected by the tool inspection department, the tool salvage department makes out a deduction notice, Fig. 3. There are seven copies of this form, which must be properly made out, showing the reasons for rejection and the disposition of rejected tools. One copy is retained in the tool salvage crib for its files, while the other copies, and all other accumulated papers, are forwarded to the purchasing department as a request for a shipping order. Upon receipt of the shipping order, all tools are delivered by the salvage department to the shipping department, which returns them to the vender.

All tools that are obsolete, worn, or broken are also sent to the tool salvage department from various parts of the shop, and disposition is made of them. Tools that have been declared obsolete are not to be used on production; they are entered on the records in the tool salvage crib and turned over to the tool distribution crib for proper storage in the obsolete tool crib. These tools in all cases are accompanied by the defective material tag. When tools become worn or broken, or when for any other reason it becomes necessary to scrap them, the tool salvage clerk examines them carefully, to ascertain if they can be repaired, or if it would be more profitable to scrap them. All scrapped tools also have a defective material tag attached to them. In all cases the tool salvage clerk should secure the signature of the proper authorities before such tools are sent to scrap. The condition of the tool received by the salvage department clerk is stated on the tag or in some other way by the tool inspection department, before it is disposed of.

The tool salvage clerk makes final disposition of all tools that do not come up to the blueprint specifications. If he does not believe that he can arrive at a reasonable decision in regard to the rejected tools, he calls in the salvage committee to act in conjunction with him, and he assumes full responsibility for prompt disposition of the tools after a decision has been reached. In general, the salvage clerk should make the final disposition of the tools received in his department, after determining the following points:

(1) Whether the tool rejected by the inspection is within the tolerance allowed for production.

(2) If the tools are not made to blueprint specifications, whether or not they are made to limits that would allow them to produce good work, and whether or not they should be given a trial.

(3) Whether the basis on which the tool is contracted for from outside sources is an hourly rate, or on a contract price. This information is obtained from the purchase order files in the tool construction department.

When a tool is made by an outside source on a contract price, it should, in all cases possible, be returned to the vender for correction, unless the need for it is very great. When the salvage department receives tools that are made by an outside source on an hourly rate, they are thoroughly investigated to see whether or not they are actually needed, and whether it would be better policy to have them repaired at the firm's expense or return them to the vender to be repaired.

When any tools are received in the tool salvage department and a change has been made in the blueprints or designs, rendering those tools useless for production, the salvage clerk ascertains whether or not the vender was given proper notice of the change of design. If the vender is found not to be responsible, the salvage clerk accepts the tools and then examines them to see if

Received from | Part No. | Purch. Ord. No. | Date | No.

Article Received | Vendors Ref. No. | QUANTITY: Received | Sent to Stores | Rejected | Held for Cor.

Receiving Report

Disposition Made By | Checked By (Gov't)

DEDUCTION NOTICE

Quantity	WHY REJECTED	Quantity	DISPOSITION OF REJECTED

Accounting Dept. Copy

Deduction Authority

Form 1840 1 10-M-8-18

Amount of Your Invoice | We Deduct above Amt. for Above Rejections at Your Price to Us | Date of This D. N. | Made out By | Above is the Amount of Your Invoice Less This Deduction

Date of Inv. | Your Inv. Reg. No. | Deducted from Inv. | Your Invoice is Approved for this Amount

Machinery

Fig. 3. Deduction Notice for Vender

they can be altered in the tool-room, so that they may be used. If they cannot be used, the tools with all information pertaining to them, are turned over to the tool distribution for final storage.

The tool salvage department should not keep complicated records. One copy of the receiving slip for all of the tools, both passed and rejected, received from outside sources, is filed under the tool number in numerical sequence. A copy of the defective material tag is filed on all material while it is passing through the tool salvage department. The department clerk renders a progress report at the end of each day, showing the receipt and actual deliveries or other disposition, and always keeps a record of the number of tools held in the salvage department. One copy of this daily progress report is sent to the tool superintendent, one to the accounting department, and one is filed for record. A similar statement is also made at the end of each week, copies of which are sent to the factory manager, the chief tool inspector, and the department file.

* * *

BUYING SECOND-HAND MACHINERY FROM THE GOVERNMENT

By DONALD A. HAMPSON

The Government has on hand vast quantities of machine tools which have been appraised in an admirable manner and which it pretends to want to sell. The inducement to buyers naturally must be that of price, because there is no other reason why one should buy from the Government rather than from the dealer, whose guarantee is of considerable value.

In going over the charts used in appraisal, one cannot fail to be impressed with the fair and comprehensive system adopted; but after the appraisal has been made, one would expect that every machine offered for sale would be tagged with the appraisal value or price. Then the buyer could consult the list, inspect the machine, and be guided by the conclusions thus arrived at. Nothing could be simpler or fairer. Some of the salvage boards have, in fact, handled the matter in this manner—notably some in the Middle West—but one of the boards located in the East has followed an entirely different policy. Statements of facts are better than statements of opinion, and for this reason the writer will merely indicate the experience that he has had in trying to obtain some machine tools in Bridgeport, Conn.

There were eight of these tools listed by the Government—two of them used. The writer's firm had a job in view which could be done very nicely on one of these machines, and it was decided to buy one of them and ask for a price for the entire lot, as the needs of replacement and future expansion might make it worth while to keep the tools in storage for some time. The machines were of a type too light for general manufacturing purposes and had always been made to order by their manufacturer, who states that there are only six shops in the country that have work for this type of machine. The itinerary for the transactions with the Government were as follows:

September 26. Visited Bridgeport, saw machines, was told by officer seen to bid whatever they were worth to us. Incidentally, saw friends who said that six dealers had put in bids for the machines at $150 for the second-hand ones.

September 27. Sent in bid for one used machine at $300. Check enclosed.

September 29. Bid rejected as too low.

September 29. Bid $350.

October 3. Bid rejected as too low.

October 3. Bid $400.

October 9. Bid rejected as too low.

October 9. Telephoned Bridgeport asking what price was settled upon for the machine.

October 11. Letter from Bridgeport saying that bid was about $100 too low.

October 13. Bid for $500. Check enclosed.

October 17. Bid rejected as too low.

October 18. Sent letter asking for an explanation of statement that $400 was $100 too low.

October 21. Received letter ignoring ours of October 18, but saying that the machine was a "new" machine.

October 28. Noticed that one of the second-hand machines had disappeared from the weekly bulletin.

November 13. In the latest Bridgeport Board's list to hand on that day saw all eight of the original machines listed as in the beginning.

November 14. Decided to try once more by bidding $600 for one of the used machines, having ascertained from the charts meanwhile that, based on the present new price and the Government's statement of use, the machine should be appraised at $592.

November 28. Bid rejected. Accompanying note says that the machine is valued at $690.

December 4. Letter saying $690 is too low, but can have machine for $700.

This is the end of the story. The job that our firm had in view has been finished on other machines. The price of $700 is entirely too high. Based upon the estimates of dealers—names including some of the best known machine tool dealers in the United States could be mentioned—the original bid of $300 was a fair value. These eight machines will probably stand for years just where they are, unless one of the six concerns in the United States that use that class of tools should be willing to pay an exorbitant price, which they are not likely to do. This is the weak point in the appraisal system which does not appear on the surface—no account of *demand* is taken into consideration.

As it appears to the writer that it is only one or a few of the salvage boards that handle their transactions in the manner outlined, this experience should not be taken as a criticism of the Office of the Director of Sales at Washington, but merely as an account of the manner in which one of the subordinate boards handles its sales, and if the detailed account given herewith will help to place the selling of the Government machine tools on a more rational basis, the purpose of this article will have been achieved.

* * *

SAVING THE COST OF A DRILL JIG

By S. B. ROYAL

The following method of providing a means for locating and centralizing the drill when drilling parts such as shown at *A* and *B* may be employed to advantage if absolute accuracy is not required in spacing or locating the holes. The method consists of providing the molds with conical shaped projections which produce small pockets in the castings or forgings at the points where holes are to be drilled. A centralizing pocket formed in this way is shown in the enlarged view at *C*. This method eliminates the necessity of providing a drill jig, and also enables the work to be done more rapidly than if a jig were used or if the work were laid out by the usual method.

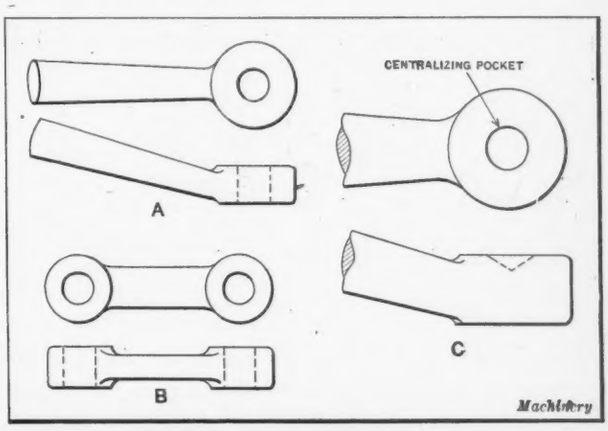


Illustration showing Pocket formed in Casting or Forging for centralizing Drill when drilling Parts such as shown at A and B

Practice in Making Component Drawings for Interchangeable Manufacture

First of Two Articles on the Application of the Principles of Dimensioning Drawings and Indicating Tolerances

By EARLE BUCKINGHAM, Engineer, Pratt & Whitney Co., Hartford, Conn.

As a practical and specific illustration of the principles governing the dimensioning of component drawings set forth in preceding articles, a small unit assembly showing the percussion firing mechanism for a large cannon is taken as an example. This particular mechanism is chosen because it is composed of a small number of parts; also because it contains several examples of comparatively unusual conditions. In studying the various component or detail drawings to be referred to, the relation between the methods of dimensioning, the tolerances and clearances specified, and the functional requirements of each part should be carefully considered.

Drawing of Firing Mechanism Assembled

The assembly of this mechanism is shown in Fig. 1. The operation is as follows: The firing mechanism container assembled must be withdrawn before the breech of the cannon can be opened, and cannot be replaced until the breech is closed. (The safety mechanism controlling this is not shown on this drawing). While this assembled container is being withdrawn, a primer *A* is inserted in the primer extractor. This primer is held in place by the pressure of the firing pin guide spring acting against the firing pin guide *B*. After the breech has been closed again, the container *C* with the primer is inserted into the housing *D* and screwed home by hand. The primer must seat tightly on the sharp taper in the spindle plug *E*. A lanyard is attached to the striker *F* with a connection that slips off when the end of the striker is withdrawn beyond the end of the container cover *G*, thus allowing the striker to move forward at the proper moment under the impulse of the firing spring *H*. The firing pin transmits the blow of the striker to the primer, thus detonating it and igniting the charge in the cannon.

Functional Requirements of the Mechanism

The following functional conditions must be maintained: The primer must be seated in the spindle plug in such a manner that no gases can escape when the gun is fired. Any leakage of these gases, which are at a very high temperature and under high pressure, will quickly erode or burn out the parts of the mechanism, thus destroying its effectiveness. This requires that the surfaces of the seat for the primer be smooth and that its dimensions be maintained within close limits. The blow imparted by the striker must be sufficient to insure that the primer will always be detonated, since the sole object of the mechanism is to detonate the primer. In order to insure this result, the firing pin must always protrude, in operation, a certain minimum distance (determined by experiments), while, in order not to pierce the primer cup, it must never protrude beyond a certain maximum distance (also determined by extensive experiments). The various unit assemblies of the mechanism must be interchangeable in order to allow quick replacements in service—a very vital requirement. As far as proves economical, the various component parts of the unit assemblies should be interchangeable to permit ready repairs in service. Unless noted otherwise, the parts of this mechanism must be interchangeable. These are the most important of the functional requirements. Others will be discussed as they arise in connection with the details.

Drawing of Firing Pin Guide

A detail drawing of the firing pin guide is shown in Fig. 2. The outside diameter is 0.782 inch plus 0.000, minus

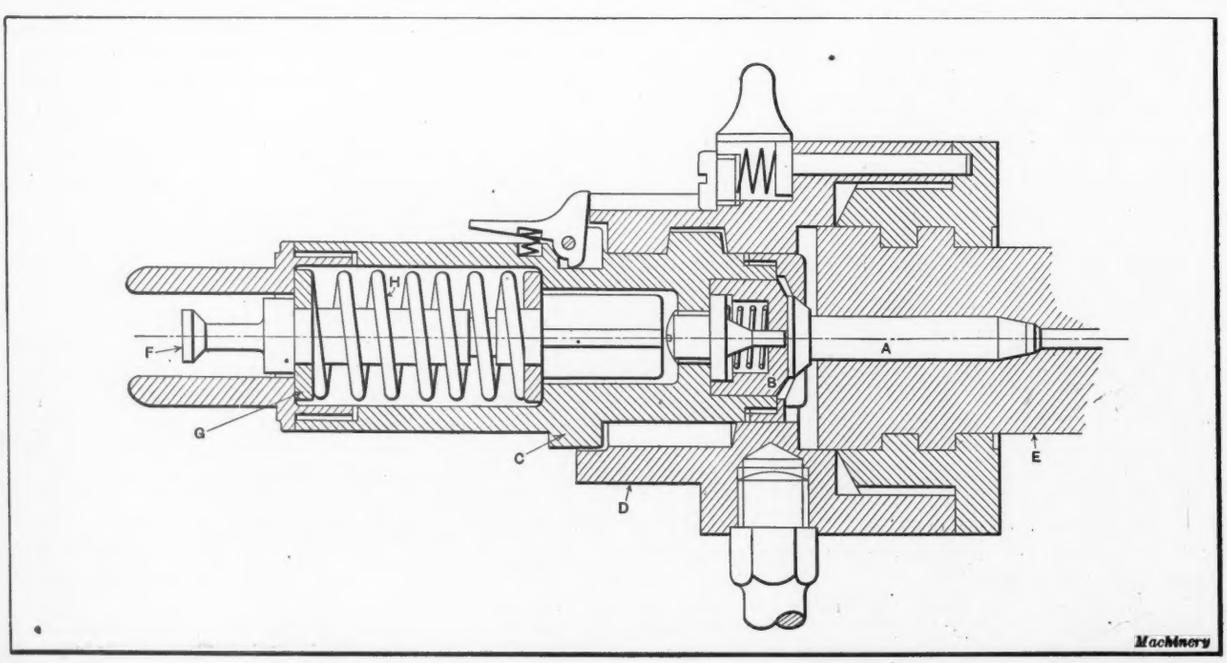


Fig. 1. Firing Mechanism assembled

0.003. This guide must be an easy slide fit in the container. It has a minimum clearance of 0.002 inch, as will be seen by a comparison with that part of the container (see Fig. 7) which receives the guide. With a tolerance of 0.003 inch on each part, it has a maximum clearance of 0.008 inch. With a reasonably smooth finish, such as that obtained by a finishing cut on the guide and a finish-reaming operation on the hole in the container, these clearances will maintain the conditions required.

The firing pin must be an easy slide fit in the guide. The diameter of the firing pin hole is 0.118 inch plus 0.003,

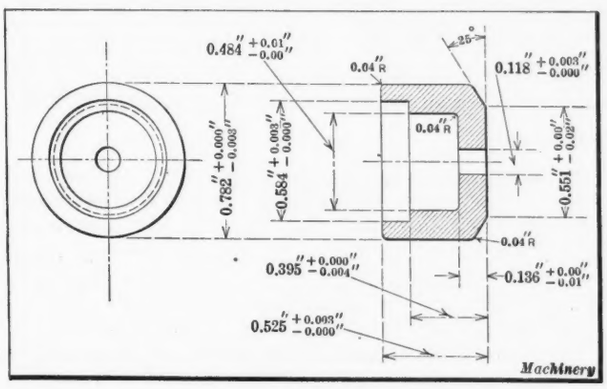


Fig. 2. Firing Pin Guide

minus 0.000. The diameter of the firing pin is 0.117 inch plus 0.000, minus 0.003; hence the minimum clearance is 0.001 and the maximum clearance (with tolerance of 0.003 on each part), 0.007 inch. With a reamed finish in the hole and a finishing cut on the pin, these clearances will maintain the proper conditions.

The diameter of the large counterbore in the rear of the guide is 0.584 inch plus 0.003, minus 0.000. The flange of the firing pin must be an easy slide fit in this counterbore. The diameter of the flange is 0.582 inch plus 0.000, minus 0.003; therefore the minimum clearance is 0.002 and the maximum clearance, 0.008 inch. With a reamed finish in the counterbore and a finishing cut on the flange of the firing pin, these clearances will maintain the proper conditions.

The diameter of the smaller counterbore is 0.484 plus 0.01, minus 0.00. This counterbore contains the firing pin guide spring. The minimum clearance is 0.020 and the maximum clearance 0.040 inch. It is apparent that this surface is of minor importance. The only limit to the increase in diameter of this surface is controlled by the width of shoulder at its mouth which is needed to act as a stop for the firing pin. The basic width of this shoulder is 0.05 inch; the tolerance on the counterbore diameter is 0.01, thus reducing the effective width of the shoulder by 0.005 inch. The tolerance specified should be sufficient to enable this counterbore to be finished in one cut. No finishing operations are necessary on this surface either for smoothness or accuracy.

An Exception to the General Rule for Basic Dimensions

The length of the guide (Fig. 2) is 0.525 inch plus 0.003, minus 0.000. This dimension is an exception to the general rule of making the basic dimension represent the maximum metal conditions, because of the functional conditions which must be maintained in this case. When the firing pin and the guide are seated solidly in the container, the face of the guide and the end of the firing pin should be as nearly flush as possible. Under no conditions must the firing pin project, because any such projection makes possible a premature explosion of the primer. The basic dimensions on the firing pin and guide are identical for this point, thus making these surfaces flush under basic conditions. The direction of the tolerances in each case is such that the pin can never project. This method of dimensioning, therefore, adheres to the principle of making the basic dimensions represent the danger point, while the direction of the tolerance is such as to move away from this danger point. On the other hand, there is another danger point in the other direction, although not as serious a one as the first. In such cases, the basic dimension should always represent the more dangerous point, while the tolerances should limit the extent of the other. In this case, the second danger point is that the end of the firing pin should be held as nearly flush with the face of the guide as possible so as not to form a pocket into which the primer cup might be forced under firing conditions. If this happens, it is very difficult to remove the exploded primer. This may retard the rate of fire and possibly put the gun out of action. The tolerances on these dimensions limit the depth of this pocket to 0.006 inch which is as great as is considered safe. The front face of the guide must be smooth; a polished surface is desirable, as this facilitates the insertion and removal of the primers.

The dimension from the bottom of the large counterbore to the front face is 0.395 inch plus 0.000, minus 0.004. This dimension controls the protrusion of the firing pin and is therefore the dimension to be maintained. Experiments show that the firing pin should protrude at least 0.026 inch in order to insure detonation, while it should not protrude over 0.034 inch or there will be danger of piercing the primer cup; therefore, the corresponding length of the firing pin is made 0.421 inch which gives the minimum protrusion of 0.026 inch while the tolerance of 0.004 inch applied to each part limits the maximum protrusion to 0.034 inch.

Maintaining a Common Locating Point

Inasmuch as the important functional dimensions of length are given from the front face, the bottom of the small counterbore is also located from that surface so as to maintain one common locating point. This surface is unimportant; a dimension of 0.136 inch plus 0.00, minus 0.01 is specified, which should give wide enough limits to enable it to be machined in a single cut.

The bevel at the front of the guide is provided to assist in the insertion of the primer. The diameter of the intersection of this bevel with the front face is given as 0.551

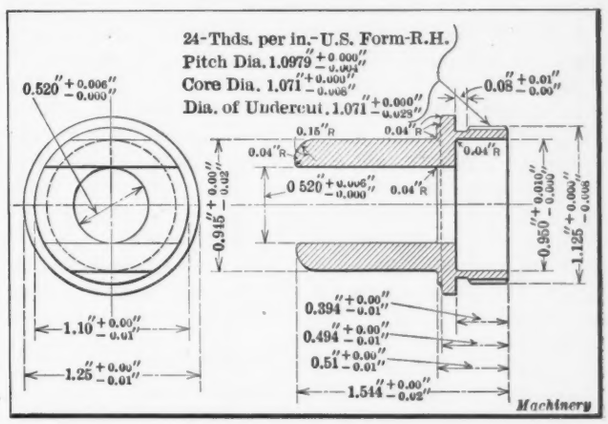


Fig. 3. Firing Mechanism Container Cover

inch plus 0.00, minus 0.02. These limits should be wide enough to meet any normal manufacturing conditions. The surface of the bevel must be smooth; a polished surface would be desirable. The angle of the bevel is given as 25 degrees. No tolerance is specified, as the permissible variation is controlled by the tolerance given for the face. The angle of the corresponding surface of the primer extractor is 14 degrees. The angle on the guide is made greater to insure that the forward corner of the guide will not project above the bottom of the primer slot in the extractor. Any such projection would interfere with the ready insertion of primers.

No tolerances are given for the radii of the corners of the guide. In the first place, a reasonable variation is

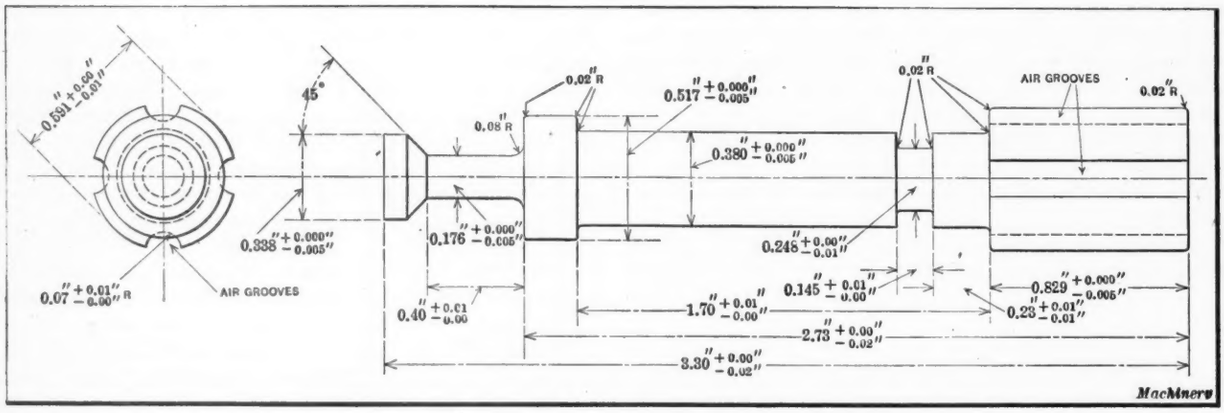


Fig. 4. Striker of Firing Mechanism

already established for them by the tolerances given on other dimensions. In the second place, their exact contour is of no importance, their purpose being to remove the sharp corners. A straight bevel of the same dimensions would be as effective.

Drawing of Firing Mechanism Container Cover

The thread of the container cover screws into the container and must be set up as tightly as possible. The outside diameter of the thread is 1.125 inch plus 0.000, minus 0.008 (see Fig. 3). The pitch diameter is 1.0979 inch plus 0.000, minus 0.004. The minimum clearance is 0.000 and the maximum clearance on the pitch or effective diameter, 0.008 inch, as will be seen by comparing Figs. 3 and 7. This tolerance should be kept as small as normal manufacturing methods will permit.

The diameter of the flange is 1.25 inch plus 0.00, minus 0.01. This surface is an atmospheric fit and of little importance, as regards either smoothness or accuracy; hence it should be completed in a single machining operation. The diameter of the stem is 1.10 inch plus 0.00, minus 0.01. This surface is an atmospheric fit and should be machined in a single operation. The distance across the flats on the stem is 0.945 inch plus 0.00, minus 0.02. This surface is for the wrench used in assembling and is of little importance. It should be machined in a single operation by a straddle-milling tool.

The diameter of the hole and the width of slot is 0.520 inch plus 0.006, minus 0.000. These surfaces are for the striker and lanyard connection. They should be as smooth as careful reaming and finish-milling operations will leave them. The hole and the slot must be matched so that no shoulder will be left at their intersection, which would retard the striker in its action. This will probably require a slight filing operation to match the cuts properly. The tolerance given should be sufficient to meet all normal manufacturing conditions. The diameter of the counterbore is 0.950 inch plus 0.010, minus 0.000. This counterbore forms a seat for the spring seat washer and is relatively unimportant. It should be finished in a single operation with a counterbore. The surface left by such a tool will be as smooth as is necessary.

All Length Dimensions Given from Logical Working Point

The dimensions of length are all given from the front surface. From a functional viewpoint, there is little choice between this surface and any of the others. The manufacturing operations will be simplified by the maintenance of one common working point. As the front surface is the logical working point, this has been chosen.

The length of the thread is 0.394 inch plus 0.00, minus 0.01. The width of the recess is 0.08 inch plus 0.01, minus 0.00. The requirements of these dimensions are that there shall be sufficient threads to hold the cover in position and that the length of this stem shall be less than the depth of the recess in the container, as the cover must always seat on its flange. The depth of the recess into which the thread projects may extend about 0.01 inch below the bottom of the threads to give a suitable clearance for threading. Also, the end of the stem and edge of the recess may be beveled about thirty degrees to facilitate this operation. The depth of the counterbore is identical with the length of the threaded stem. This depth is of relatively small importance.

The location of the rear face of the flange is 0.494 plus 0.00, minus 0.01. This surface is an atmospheric fit and should be finished in a single operation. The bottom of the wrench cuts is 0.51 plus 0.00, minus 0.01. This is a clearance surface of little importance. It is left above the rear surface of the flange to eliminate all matching operations. The bottom of the slot is located by these same dimensions, and its surface is of equal unimportance.

The length over-all is 1.544 inches plus 0.00, minus 0.02. The rear surface of the cover is an atmospheric fit of minor importance. No tolerances have been specified for any of the radii, as their exact contour is of no importance. Their purpose is to remove the sharp corners. Furthermore, sufficient variations have been established for these radii by the tolerances on other dimensions.

Drawing of Striker

The diameter of the front end of the striker (see Fig. 4) is 0.591 inch plus 0.00, minus 0.01. This surface must clear the counterbore in the container (see Fig. 7). The minimum clearance is 0.019 inch and the maximum clearance 0.039 inch. The radius of the air grooves is 0.07 inch plus 0.01, minus 0.00. No finishing cuts are required on these surfaces. The stem which has a diameter of 0.38 inch plus 0.000, minus 0.005, must be a free sliding fit in the spring seat washers. The minimum clearances are 0.002 inch and the maximum 0.012 inch. This stem must have a smooth surface, such as will be secured by a finishing tool.

The rear shoulder which has a diameter of 0.517 inch plus 0.000, minus 0.005, must be a free sliding fit in the cover. The minimum clearance is 0.003 inch and the

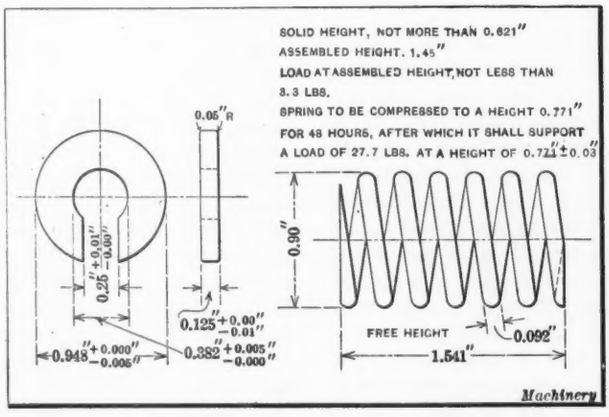


Fig. 5. Spring Seat Washer

SOLID HEIGHT, NOT MORE THAN 0.621"
ASSEMBLED HEIGHT, 1.45"
LOAD AT ASSEMBLED HEIGHT, NOT LESS THAN 3.3 LBS.
SPRING TO BE COMPRESSED TO A HEIGHT 0.771" FOR 48 HOURS, AFTER WHICH IT SHALL SUPPORT A LOAD OF 27.7 LBS. AT A HEIGHT OF 0.721" ± 0.03"
0.90"
FREE HEIGHT
0.092"
1.541"
Machinery

Fig. 6. Firing Spring

maximum clearance 0.014 inch. This surface must be as smooth as a careful finishing cut will leave it. The length of the front end (0.829 inch plus 0.000, minus 0.005) should be held within reasonably close limits in order to insure a uniform blow on the firing pin. Variations in this dimension will affect the force of this blow. The front face of the striker must be as smooth as a finishing cut will leave it. The length of the stem (1.70 inches plus 0.01, minus 0.00) should also be held within reasonably close limits, as it controls, to a certain extent, the force of the blow of the striker. This stem could be machined with a form tool, the roughing tool being made to form the neck for assembling the washers. The neck is, therefore, located from the front end of the stem, the dimension being 0.23 inch plus 0.01, minus 0.01. The width is 0.145 inch plus 0.01, minus 0.00. These limits should be adequate to permit this groove

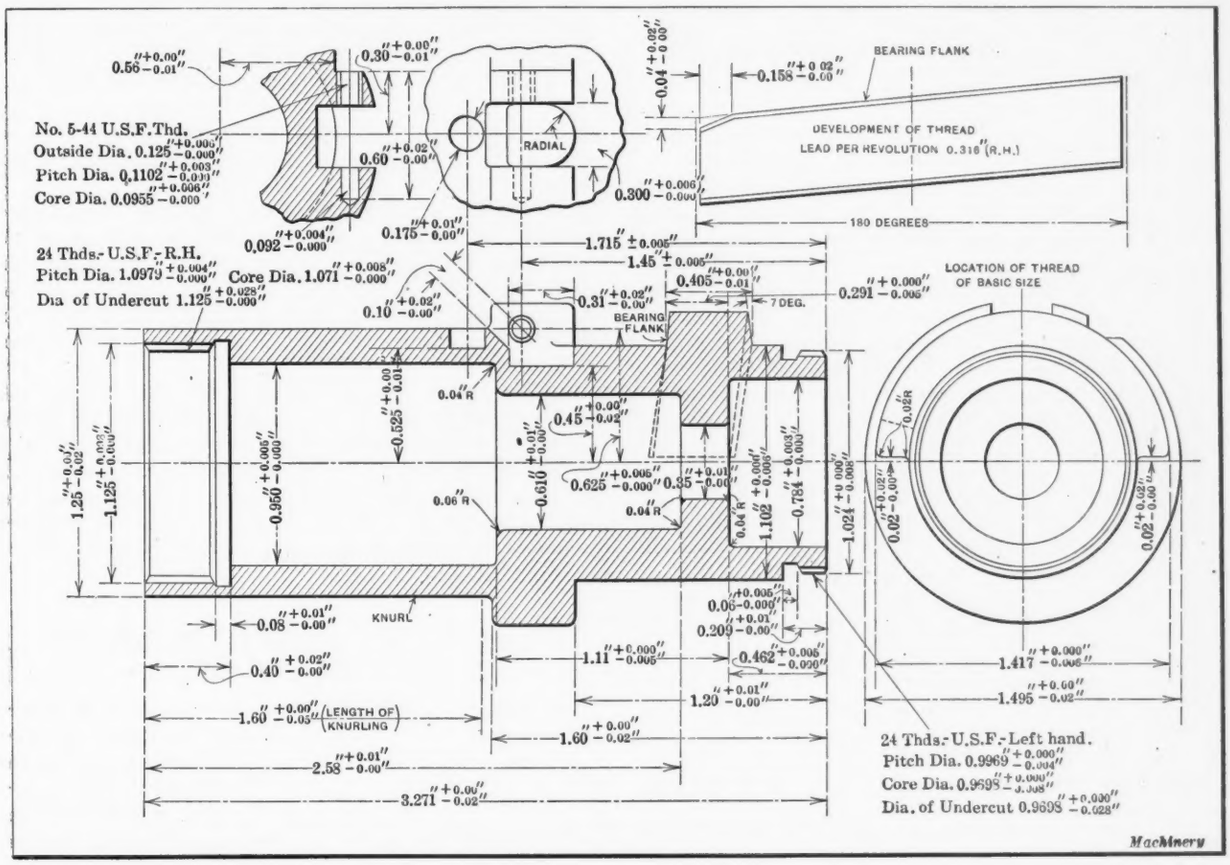


Fig. 7. Firing Mechanism Container

to be finished with a roughing tool without any unnecessary refinements.

The location of the rear shoulder from the front end (2.73 inches plus 0.00, minus 0.02) and the width of the bottom of the groove (0.40 inch plus 0.01, minus 0.00) are relatively unimportant. The surfaces, however, must be reasonably smooth ones such as are obtained with a finishing tool. These limits should be sufficient for all manufacturing purposes. The length over all (3.30 inches plus 0.00, minus 0.02) is also relatively unimportant. A sufficiently smooth surface for the rear end will be obtained with a cutting-off tool.

No tolerances are given for the 45-degree bevel at the rear end, nor for the radii, because none are required. A reasonable variation is already established by tolerances given on other dimensions. Sufficiently accurate radii will be obtained by touching with a file the various corners which are not broken by form tools, to remove the sharp edges.

Drawing of Spring Seat Washer

If a large number of spring seat washers (see Fig. 5) were to be manufactured, they might be made in a punch and die. The surface obtained in a well made sub-press die would be sufficiently smooth, but the surface obtained on the usual punch press in an open die would probably require some polishing. For a small number of parts, bar stock could be used. The surface obtained with a finishing tool would be satisfactory.

The hole must be a free sliding fit on the stem of the striker. The minimum clearance is 0.002 inch and the maximum clearance 0.012 inch. A surface equal to that obtained with a reamer should be secured. The width of the assembling slot is unimportant. The faces of the washer are of but minor importance. The original surface of flat stock, if that is used, or the surface obtained with a cutting-off tool, if bar stock is used, will be satisfactory.

Tolerances are not needed for the radius of the corners, but enough of the corner must be removed to permit the washer to seat properly in the counterbore in the cover. It will be satisfactory to remove this corner on a polishing wheel or with a file in the lathe.

Drawing of Firing Spring

No tolerances are given on the dimensions of the firing spring (see Fig. 6), because the functional requirements are covered by the weight specifications, and the manufacturer is allowed reasonable latitude in these dimensions as long as the weight requirements are maintained. The dimensions given are nominal. A variation of 0.005 inch in the diameter of the wire, or of 0.030 inch in the diameter of the coils or free length of the spring will be of no moment. If these tolerances were expressed on the drawing, some manufacturer would complain that the weight specifications would not allow him to take full advantage of them, and would seek to have the weight requirements altered or removed. These weight conditions are the essential ones, as they control the force of the blow on the primer. A minimum load of 3.3 pounds is required at the assembled height of 1.45 inches. A load of 27.7 pounds is required at a height of 0.771 inch plus 0.03, minus 0.03. By thus specifying loads at two heights, the strength of the spring is very closely controlled.

Drawing of Firing Mechanism Container

The container is shown in Fig 7. The housing thread (which has an outside diameter of 1.417 inches plus 0.000, minus 0.006) is a special thread and will undoubtedly be milled. It must be a very free fit in the housing, as the container is inserted and removed every time the gun is fired. It must assemble readily, even if a certain amount of dirt and grit is present. The minimum clearance is 0.008 inch and the maximum clearance 0.020 inch. The surfaces must be smooth. A finish-turning or milling cut will be satisfactory. It will be necessary to match the turning and milling cuts where the bottom of this thread matches the cylindrical portion of the container with a file after the part is machined.

The thread for the primer extractor (outside diameter 1.024 inches plus 0.000, minus 0.008) must be left hand to prevent the primer extractor from unscrewing as the mechanism is removed from the housing. The minimum clearance is 0.000 and the maximum clearance on the pitch or effective diameter, 0.008 inch. The primer extractor must be screwed home as firmly as possible, and the variations on these threads should be kept as small as normal manufacturing methods will permit.

The small counterbore in the rear end (diameter 0.610 inch plus 0.01, minus 0.00) is for clearance and is unimportant. It should be finished at a single operation of a counterbore. The large counterbore in the rear end (diameter 0.950 inch plus 0.005, minus 0.000) must be a free sliding fit for the washer and should be reamed. The minimum clearance between the hole having a diameter of 0.35 inch plus 0.01, minus 0.00, and the firing pin is 0.05 inch, while the maximum clearance is 0.07 inch. This surface is unimportant and should be machined by a single drilling operation. The diameter of the counterbore in the front end is 0.784 inch plus 0.003, minus 0.000. This surface must be an easy sliding fit for the guide and requires a careful finish-reaming operation. The length over all (3.271 inches plus 0.00, minus 0.02) is relatively unimportant, yet both the front and the rear faces must be smooth, as they form the seats for the cover and primer extractor. The majority of the length dimensions are located from the front face. A few are given from the rear end because of manufacturing considerations. The remainder are given from intermediate points because of the functional requirements of the mechanism.

The length of the thread for the extractor is 0.209 inch plus 0.01, minus 0.00, and the width of the under-cut, 0.06 inch plus 0.005, minus 0.000. The requirements of these dimensions are that there shall be sufficient threads to hold the extractor properly and that the length of the stem be always long enough to permit the extractor to seat on the front face of the container.

The bottom of the large counterbore, which is 1.11 inches plus 0.000, minus 0.005, from the firing pin seat, is an important functional surface and should be finished by a special operation, locating from the firing pin seat. This dimension controls, to a great extent, the force of the blow of the striker. The location of the housing thread is also controlled from the firing pin seat. This dimension (0.291 inch plus 0.000, minus 0.005) controls the angular position of the mechanism when it is screwed home in the housing. A plus variation on this dimension might prevent the mechanism from locking. The width of the housing thread is 0.405 inch plus 0.00, minus 0.01. The rear surface or flank of this thread is a bearing surface and must be smooth. A corner of this rear flank is beveled with a file to facilitate entering the housing (see view showing development of thread). The length of bevel is 0.158 inch plus 0.02, minus 0.00, and the width of bevel 0.04 inch plus 0.02, minus 0.00. This should give sufficiently liberal tolerances for all manufacturing purposes. Double this tolerance could be given, however, if necessary.

The latch-pin and spring holes are both located from the front face of the container, as this is the logical locating point for the drill jig. The distance from the latch-pin hole to the center of the container is 0.625 inch plus 0.005, minus 0.000. A minus variation on this last dimension would develop interference between the bottom of the slot and the latch. The latch-pin thread is a standard No. 5-44 A.S.M.E. thread. Taps should be available from stock from any reliable tap manufacturer. This is a fine thread and should be held as close to size as normal manufacturing conditions will permit.

The distance to the cut on the left side of the flange is 0.30 inch plus 0.00, minus 0.01, and the height from the bottom of the cut is 0.56 inch plus 0.00, minus 0.01. The requirements of this cut are that the cutter shall not gouge the knurled handle by cutting too deeply and that the tap shall not gouge the bottom of this cut. The limits specified give the greatest permissible variations under maximum metal conditions and should be great enough to allow this cut to be machined in a single operation. The width of the latch slot is 0.300 inch, plus 0.006, minus 0.000. This surface must be reasonably smooth so as to maintain an easy action of the latch. The minimum clearance is 0.003 inch and the maximum clearance, 0.013 inch. With the proper surfaces, these clearances will maintain the desired conditions.

The location of the bottom of the slot from the center of the container is 0.45 inch plus 0.00, minus 0.02. A plus variation on this dimension would develop interference with the latch. The surface of the bottom and ends of this slot is not important and requires no finishing cuts. The cuts on the side of the slot must be matched to provide a smooth bearing for the latch.

The ends of the housing thread are 0.02 inch plus 0.02, minus 0.00, from the center of the container. These surfaces require no finishing cuts. The length of the knurling is 1.60 inches plus 0.00, minus 0.05. A scale measurement will be sufficient to check this dimension. No tolerances are given on the various radii or angles, as none are required. Tolerances on other dimensions establish liberal variations for these surfaces.

* * *

REDUCING ACCIDENTS BY SYSTEMATIC EFFORT

An interesting report of the reduction in accidents at the Ford motor and ship plants is made by Robert A. Shaw of the Department of Safety and Factory Hygiene of the Ford Motor Co., Detroit, Mich. According to this report, the number of accidents has been materially reduced in the last three years, the number of lost-time accidents in October, 1916, being 194, while in April, 1919, there were only 32. By lost-time accidents is meant accidents in which eight or more consecutive hours are lost from work. This is a reduction of 83.5 per cent in two and a half years. In October, 1916, the number of employes who had to take some time off because of accidents amounted to 4.8 per thousand employes. In April, 1919, this number was reduced to 0.8 per thousand employes. The record covers in both cases 49,800 employes. If the number of work-hours and the number of hours lost through accidents are compared, it will be found that the plant had an efficiency rate of 99.95 per cent, which is probably as high a record as most plants could show. In addition, it is pointed out that in a plant employing about 50,000 men, nine months were passed during the fiscal year 1918-1919 without a fatal accident, and in 1917-1918 eleven months were passed without a fatal accident. In addition to ordinary care taken in shop operations, electric tripping devices have been installed on all large punch presses. It is interesting to note that the use of these devices has not only practically eliminated all accidents to hands and fingers on the presses, but has also increased the production about 10 per cent. Incidentally, the fatigue of operators has been greatly reduced through the elimination of the foot tripping device. At the Ford Eagle plant the reduction in the number of accidents was 75 per cent.

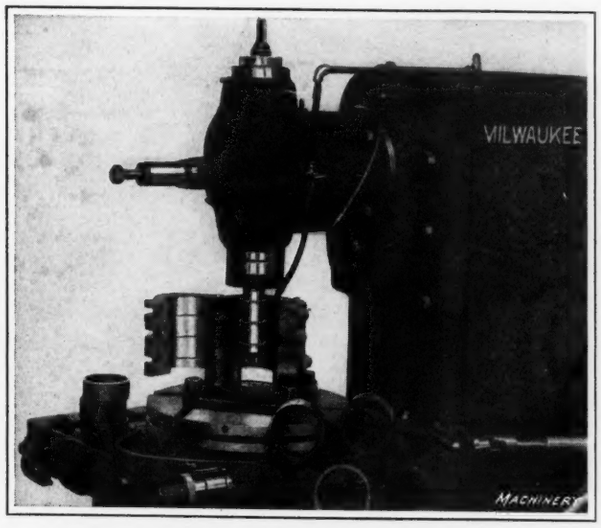


Fig. 10. Unusual Form of Fixture provided on a Kearney & Trecker Machine used by the Hyatt Roller Bearing Co. for milling Grooves in Outer Raceways of Roller Bearings

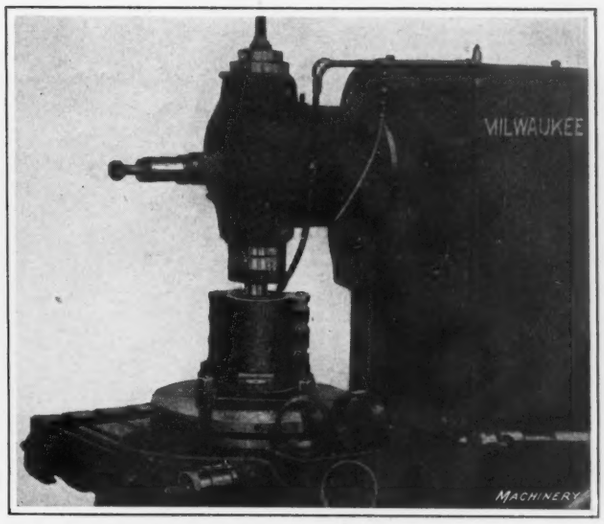


Fig. 11. Same Milling Machine and Work-holding Fixture illustrated in Fig. 10, but with the Fixture closed, Ready for milling the Three Retainer Anchorage Grooves

String Milling Fixtures

A Discussion of Typical Examples of Design and Results Obtained in Operating the Fixtures—Second of Two Articles

By EDWARD K. HAMMOND

IN the December number, string milling fixtures employed for milling gear-box levers, clutch shifter forks, connecting-rods, and racks were described. In the following, additional examples of string milling fixtures are presented.

Milling Hudson Crankshaft Bearing Caps

On passenger cars built by the Hudson Motor Car Co., heavy aluminum caps are used for the crankshaft bearings. In machining these caps, it is necessary to perform milling operations on four faces of the work, and in order to allow all of these surfaces to be milled simultaneously, a milling machine built by the Kearney & Trecker Co., of Milwaukee, Wis., is equipped as illustrated in Fig. 12. It will be seen that four cutters are mounted on the arbor—two inserted-tooth mills for facing the large side surfaces of the work, and two plain cutters for milling the small surfaces at each side of the bearing groove. Four pieces of work are mounted in a string fixture on the table, and this fixture is equipped with a quick-acting clamping mechanism in order to facilitate the rapidity with which the pieces may be loaded in the fixture, or removed after the milling operation has been completed. Between each pair of bearing caps there is placed a bolt *A*, which holds down a semi-cylindrical shaped strap *B* that fits into the bearing groove in the two caps at each side of this clamping bolt.

It will be noticed that the hole in strap *B* is made of sufficient size to clear the nut on bolt *A*, so that the strap may be dropped over this bolt and then pushed sidewise in order that the groove cut in the side of the hole may allow the strap to slide under the nut ready for clamping it down on the work. It will be quite obvious from Fig. 12 that provision must be made for so locating the work that the sides of the bearing caps will be milled square with the ends. This result is accomplished by having small blocks *C* placed on the bed of the fixture, which come into contact with ribs extending across the sides of the work. The way in which these blocks *C* locate the work will be readily understood by referring to the piece which is shown clamped in place on the fixture. Owing to the different sizes of the cutters used for the performance of this milling operation, the speeds vary considerably, the rates employed being 280 and 220 feet per minute, respectively, with a feed of 18 inches per minute. In quoting these speeds and feeds, it is repeated that the material is aluminum; otherwise, such rates could not be successfully employed. In an eight-hour working day, the output of each machine is 700 bearing caps.

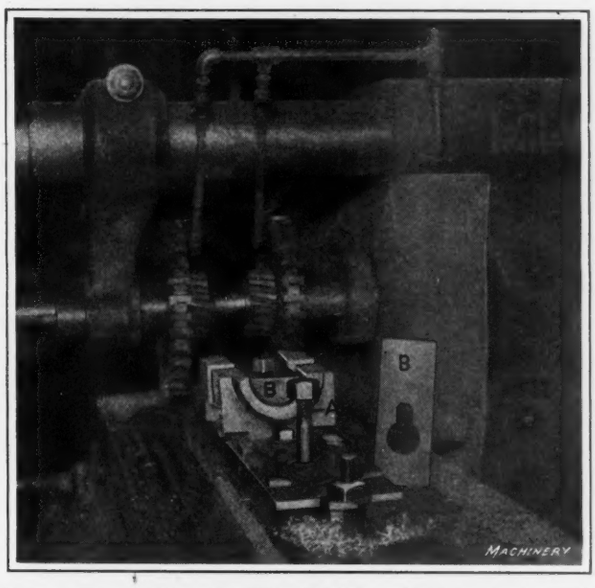


Fig. 12. Kearney & Trecker Milling Machine equipped for simultaneously milling Four Faces of Hudson Crankshaft Bearing Caps

Milling Retainer Rings in Roller Bearing Raceways

In the process of making roller bearings of the type manufactured by the Hyatt Roller Bearing Co., Newark, N. J., it is required to mill grooves in the outer raceways to form an anchorage for the roller retainers. There are various methods by which this operation could be performed, but probably there are few which would enable as efficient results to be obtained as those which are secured through the use of a Kearney & Trecker vertical-spindle milling machine equipped with a rotary table and work-holding fixture of the type shown in Figs. 10 and 11. In Fig. 10 it will be seen that three slitting saws are mounted on the arbor, which are 1/16 inch in width;

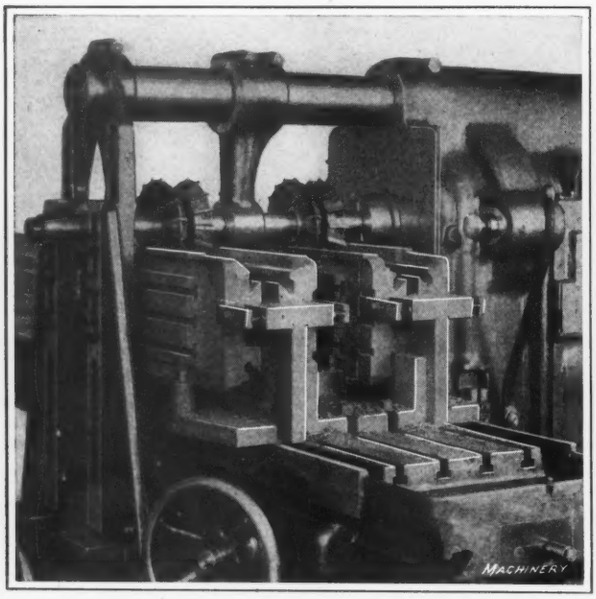


Fig. 13. Rough-milling Angular Sides of Slides on Milling Machine Tables at the Brown & Sharpe Mfg. Co.'s Plant, using a No. 5B Milling Machine of this Company's Manufacture

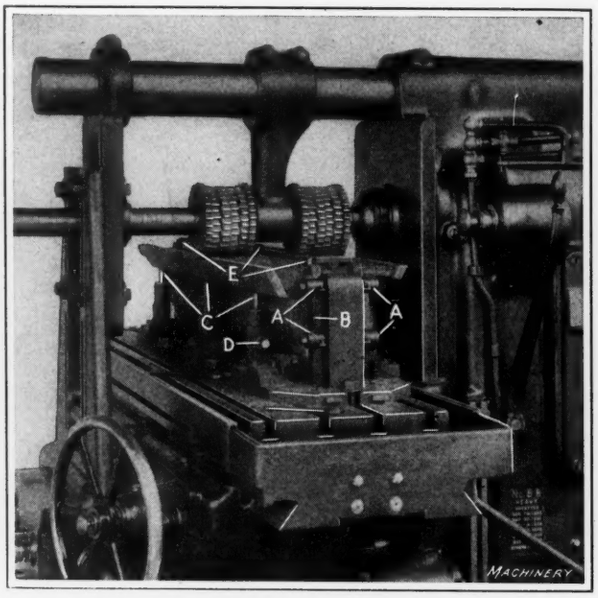


Fig. 14. Milling Operation simultaneously performed on Two Grinding Machine Tables in the Brown & Sharpe Mfg. Co.'s Plant, using a No. 5B Heavy-duty Brown & Sharpe Milling Machine

that is, the proper width for cutting the retainer grooves in the roller bearing raceways. The fixture mounted on the rotary table of this machine provides for holding three raceways, in each of which the retainer groove is cut by one of the saws. As each raceway is located in this fixture, the two half rings which hold it in place are bolted together. Then after all three pieces have been set up, the rotary table is started, and also the transverse feed movement. As the rotary table revolves the work, the saws cut continuous slots all the way around the three pieces held by the fixture. A limit stop for the transverse movement of the table stops this feed when the slots have been milled in the work to the required depth. The parts being milled are pieces of seamless steel tubing, and the rate of production obtained is three pieces per minute.

Milling Footstocks for Spiral Heads

Fig. 15 shows a Brown & Sharpe No. 3B heavy-duty type of plain milling machine equipped for facing off the sides and milling the center space of footstocks for spiral heads. This operation is of interest owing to the height of the side surfaces which have to be milled, making it necessary to employ a gang of cutters of unusually large diameter. It will be apparent from the illustration that three castings are set up in a string fixture, so that they can all be milled at a single traverse of the table. The outsides of the uprights on these castings are faced, and the space between the two uprights is cut to the required width. Side milling cutters with inserted teeth are employed for this job, these cutters being 12 inches in diameter. The two outside cutters have their teeth set parallel with the axis of the arbor on which they are carried, because the face width is not great enough to cause an objectionable amount of shock when the teeth engage the work, or other undesirable conditions of operation which are obviated through the use of milling cutters with spiral teeth. The middle cutter, which is of greater face width, has the teeth set at an angle with the axis of the arbor, in order to produce a shearing action, and these teeth are nicked to break up the chips. It will be apparent that the fixtures used for holding the work while performing this milling operation are of extremely simple design, consisting merely of bolts fitted into the T-slots on the table to provide for holding straps down on the flange which extends around the base of each footstock casting. The machine is shown in operation at the plant of the Brown & Sharpe Mfg. Co., in Providence, R. I.

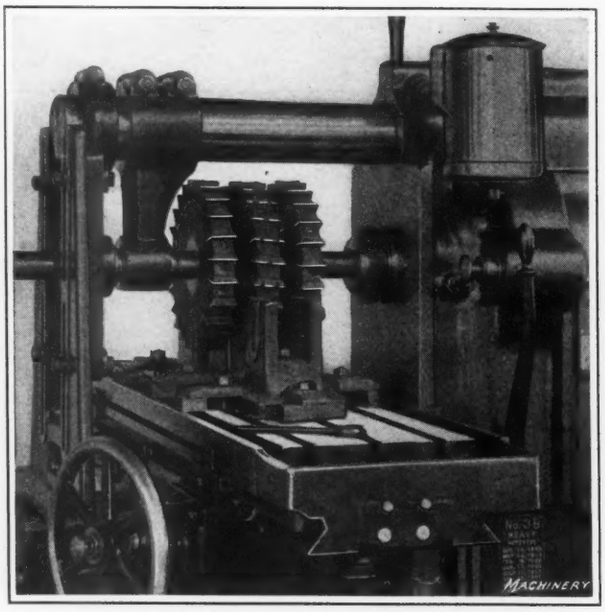


Fig. 15. Milling Footstocks for Spiral Heads at the Plant of the Brown & Sharpe Mfg. Co. This Operation is performed on a No. 3B Heavy-duty Plain Milling Machine of this Company's Manufacture

Multiple Work-holding Fixtures Placed Side by Side

The term "string milling fixture" is generally applied to that class of fixture in which the castings are placed in a row on the milling machine table, running in a direction parallel to the line of travel of the table. With such an arrangement, provision is made for milling all of the castings with a single cutter, or gang of cutters, mounted on the arbor. In some cases, however, it may be found more desirable to set up the work in fixtures that provide for holding the castings or forgings side by side, instead of end to end. A case in point is illustrated in Fig. 13, which shows a Brown & Sharpe No. 5B plain milling machine engaged in simultaneously rough-milling the angular sides of the slides on four milling machine tables. The machine is shown in operation at the Brown & Sharpe plant. This is the kind of job that could be performed on a planer or slabbing type of milling machine equipped with a table of sufficient length to set the four castings up end to end; and if such a practice were followed it would only be necessary to use one milling cutter. However, by performing the operation as shown in Fig. 13, a less expensive

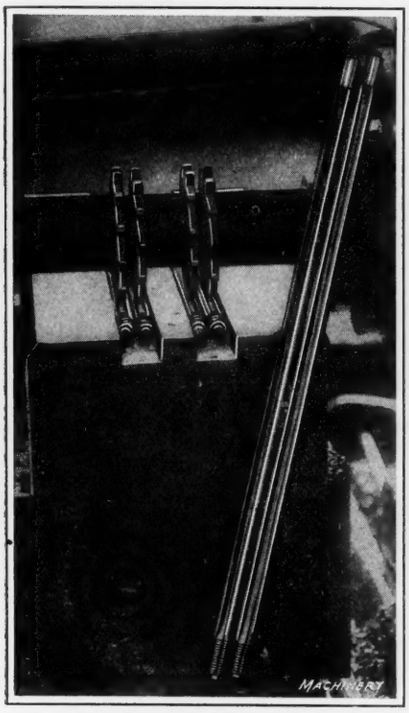


Fig. 16. Briggs Miller built by Gooley & Edlund, engaged in milling Grooves in Carriage Roll Guides at the Plant of the Royal Typewriter Co.

machine is utilized; but in order to do so it is necessary to set the castings up side by side, because the length of the table is insufficient to mount them in a single row. It will be seen that the castings are set up on two knee type fixtures, each of which provides for holding two castings, one on each side of the fixture. The same fixture is used to mill the opposite angular sides of the slide, the four pieces of work being merely turned over and reset for taking the second cut.

At the plant of the Brown & Sharpe Mfg. Co., No. 5B plain milling machines of this company's manufacture are used for simultaneously performing a milling operation on two tables for Brown & Sharpe grinding machines, as shown in Fig. 14. The reason for setting up the castings side by side on this machine is the same as that explained in connection with the job illustrated in Fig. 13. The two grinding machine table castings are held at opposite sides of a knee fixture, and two gangs of cutters, with six in each gang, are employed for simultaneously milling the various surfaces which have to be finished. To provide for holding these castings back against the locating points, there are four straps *A* at eacn end of the fixture, these straps being provided with lugs which project inward to engage the flange *B* on each end of the castings that have to be milled. By tightening the nuts over straps *A*, the lugs on these straps pull the work securely back against the locating points. Owing to the form of the castings to be milled, it is necessary to afford means of supporting the work to avoid danger of its being distorted through pressure applied by the milling cutters. Such means are furnished by three spring plungers *C*, which come into engagement with the inside of the work, after which nuts *D* are tightened to lock these

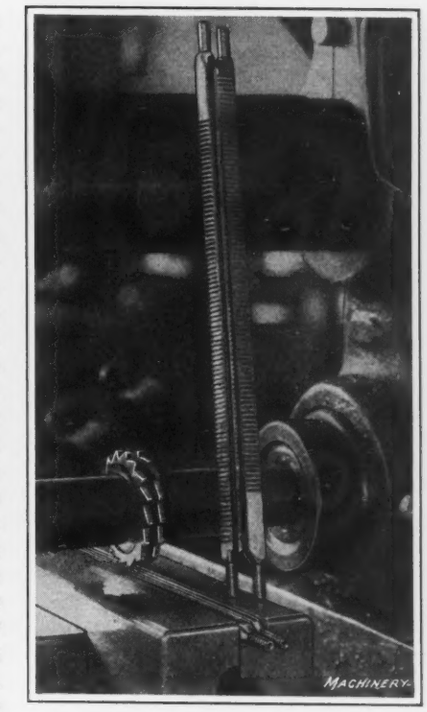


Fig. 17. No. 2 Becker-Brainard Plain Milling Machine equipped for milling Grooves in Two Tabular Rods at the Plant of the Royal Typewriter Co.

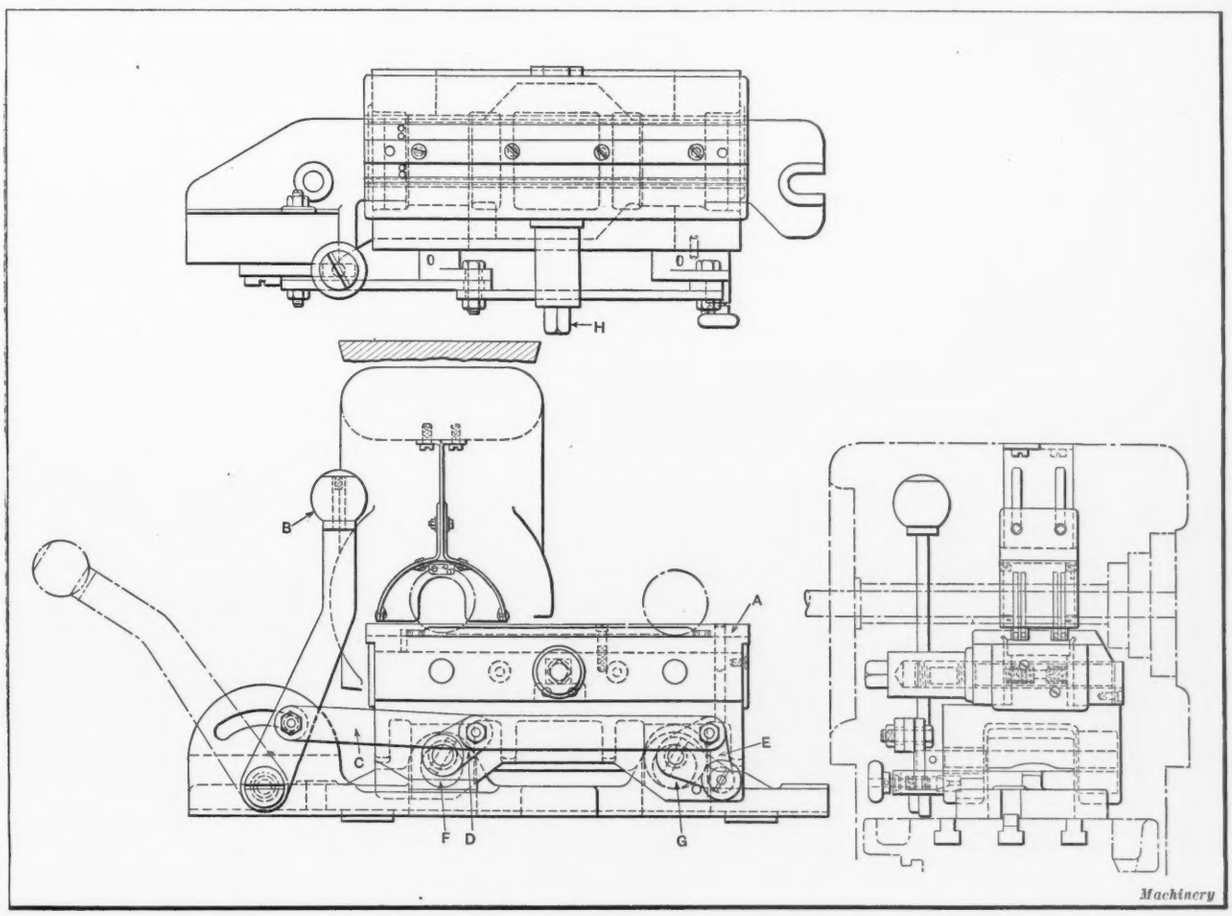


Fig. 18. Design of Elevating Device for Work-holding Fixture used on Briggs Milling Machine shown in Fig. 16

plungers in place. Additional support is furnished for the work by means of three straps *E*, which straddle the two castings and provide for holding them firmly against the locating points on the fixture, in addition to keeping them down in place.

Milling Typewriter Carriage Roll Guides to Reduce their Weight

At the plant of the Royal Typewriter Co., Inc., of Hartford, Conn., a large number of parts known as carriage roll guide rods are required, these pieces being of the form shown in Fig. 16. It is important to reduce the weight of all typewriter parts as far as possible, without seriously impairing their strength. To provide for cutting down the weight of the rods shown in Fig. 16, a practice is made of milling a longitudinal slot along the back side of each rod, in order to remove as much surplus metal as possible. This job is done on one of the Briggs milling machines built by Gooley & Edlund, Inc., Cortland, N. Y. It will be evident that provision is made for setting up four of the carriage roll guides at a time, the fixture consisting of a special form of vise provided with two openings, in each of which two of the carriage roll guide rods can be mounted. The jaws are slightly under-cut so that when they are tightened on the work, they serve the double purpose of gripping it and forcing it downward so that an accurate location and secure hold are obtained simultaneously. The two outer jaws move inward in opposite directions, and grip the work against the central jaw, which constitutes the fixed jaw for each of the two vise openings.

Rather an unusual type of fixture is used on this machine to provide for feeding the work up against the milling cutters, in order to cut grooves of the required depth in the carriage roll guide rods. This fixture is merely a sub-table on which the special milling vise is mounted, and by simply throwing over a lever, provision is made for raising the work against the milling cutters so that the groove will be cut to exactly the proper depth. The reason for following this procedure will be made quite evident by referring to the form of the work shown in Fig. 16, where it will be seen that at each end of the carriage roll guide there is a threaded section, while the groove milled in the work projects beneath the level of the threads. Consequently it is not possible to mill the groove by a single horizontal feed movement of the table; the work must be raised into engagement with the milling cutters at the point where the groove starts, and then lowered away from the cutters at the opposite end of the groove. By this method of procedure, the groove is cut to the proper depth and the threads at either end of the work are not damaged.

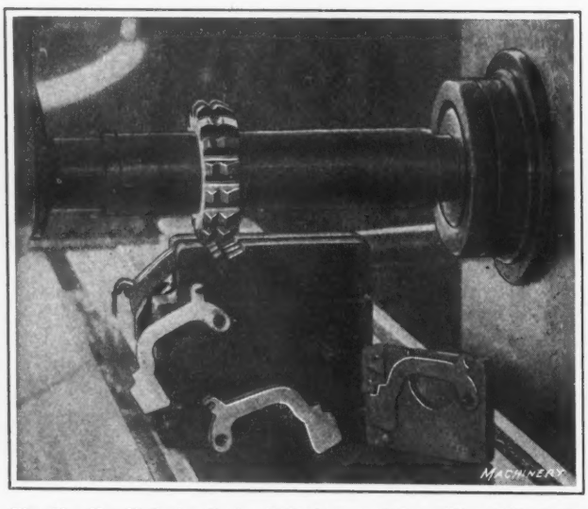


Fig. 19. No. 25 Becker-Brainard Machine used for milling Shift Locks for Royal Typewriters. Five Pieces are held in the Vise, with a Locating Pin passing through a Hole in Each Piece of Work

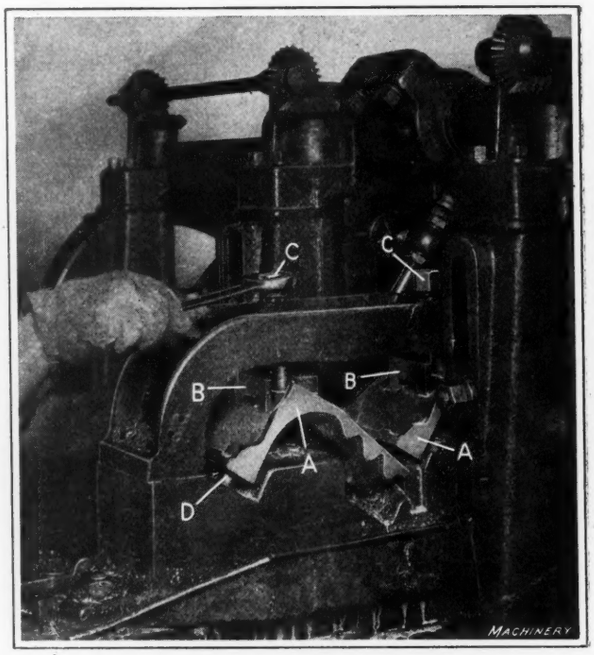


Fig. 20. No. 8 Double-head Lincoln Miller built by the Hendey Machine Co., and used by the Dayton Engineering Laboratories Co. for milling Self-starter Generator Frames

Reference to Fig. 18, while reading the following description, will give a clear idea of the way in which this fixture operates. The vise which holds the work is shown at *A*, and in order to raise this vise and to bring the pieces carried by it into engagement with the milling cutters, it is merely necessary to throw lever *B* over from the position indicated by broken lines to the position where the lever is shown by full lines. It will be seen that attached to lever *B* there is a link *C*, which has two pivoted levers *D* and *E* secured to it. These two pivoted levers are keyed to the ends of two eccentric shafts *F* and *G*, which are free to rotate in close-fitting bearings. When lever *B* is pushed forward to the position shown by the full lines, the motion is transmitted through links *C*, *D*, and *E*, to the eccentric shafts *F* and *G;* and the rotation of these eccentrics, which are held in a fixed position, results in imparting a vertical movement to the bed of the fixture and the work carried by the vise mounted on it. After the horizontal feed movement has advanced the cut to the far end of the groove which is required in the work, lever *B* is simply pulled back to lower the work out of engagement with the cutter, so that the threaded ends of the carriage roll guide rods will not be damaged. Stops are furnished to locate the starting and stopping points of the cut. The vise jaws, between which the four pieces of work are held, are tightened by turning the square end of screw *H* which is threaded right-hand at one end and left-hand at the opposite end, to provide for moving the two outer jaws in opposite directions. A special form of ratchet handle is provided to go on this square end of the operating screw, so that the vise jaws may be tightened or loosened by a reciprocating action of this lever, which is far more convenient than having to make complete rotations of a crank handle. The work to be milled is made of cold-rolled steel and the slots are 10 inches long; the rate of production obtained is 325 pieces in a nine-hour working day.

Milling Slots in Tabular Rods of Royal Typewriters

Fig. 17 shows a Becker-Brainard No. 2 plain milling machine equipped for milling grooves in two tabular rods for Royal typewriters. This operation is quite similar to the one which has just been discussed in connection with the two preceding illustrations. But the work-holding fixture is of a less highly perfected form, as provision is only made for setting up two pieces of work at a time,

so that the percentage of a full working day during which the machine is idle is substantially increased. The influence of such a condition upon the daily output of work is indicated by the fact that on this job the rate of production obtained is only 200 pieces per nine-hour day, instead of 325 pieces secured on the equipment shown in Fig. 16. In order to emphasize the fact that these two jobs are entirely comparable, mention is made of the fact that the length and cross-sectional area of the groove to be milled is the same for both jobs, and the parts are both made of cold-rolled steel. The special form of fixture for raising the work into contact with the milling cutters is not required in this case, because, although the work is threaded at each end, the diameter of the threaded sections is sufficiently reduced from the height of the body of the work, so that the milling cutters may be fed straight across the work without damaging the threads. On both of these jobs the work is kept flooded with lard oil.

Form-milling Shift Locks at the Royal Typewriter Plant

At the front of the work-holding fixture illustrated in Fig. 19, there are shown two of the finished shift locks which are form-milled on their upper surface by means of the equipment shown in this illustration. After being milled, these parts are gaged, as shown at the right-hand side of the illustration, in order to make sure that they fulfill the specified requirements. Reference has already been made to some of the ways in which milling vises of standard or special design can be utilized for the performance of milling operations on production work, but in the present instance a rather different scheme is followed from any which have previously been mentioned. The illustration clearly shows the way in which the form milling cutter on the arbor is used to obtain the required contour for the top surface of the work. It was not felt, however, that this could be performed with the required degree of accuracy if the edges of these thin stampings that have to be milled were allowed to project the required distance above the jaws of the vise. Consequently, the tops of these jaws were milled to the same contour that it is required to produce on the work; and with such an arrangement, the pieces can be clamped between the jaws in a manner that assures complete support without in any way hampering the work of milling them. Five stampings are set up in the vise at a time, and the pierced hole in one end of the stampings is utilized as a locating point, by slipping the hole in the work over a locating pin that is provided in one of the vise jaws for the purpose. This job is done on a Becker-Brainard No. 25 plain milling machine, and the rate of production obtained in performing this operation is 350 shift locks from one machine in a nine-hour working day.

Milling Generator Frames for Automobile Self-starters

Fig. 20 illustrates a method employed by the Dayton Engineering Laboratories Co., of Dayton, Ohio, for tooling up and operating a No. 8 double-head Lincoln milling machine built by the Hendey Machine Co., Torrington, Conn., for use in simultaneously milling both sides of the frames of electric generators for the self-starting and ignition system on Buick motor cars. It will be apparent from this illustration that the fixture is designed to hold two pieces of work which are shown at *A*. After the piece that is located nearest the cutters has been set up, the feed is started and the operator then proceeds to set up the second piece. This method works out nicely, because the length of cut is ten inches, so that ample time is afforded to set up the second piece before the cut has been completed on the first casting. The use of such a plan is also the means of keeping the machine operator employed during the greater part of the day. These generator frames are made of malleable iron, and on this job, the rate of production is 300 pieces in a working day of nine and three-quarter hours.

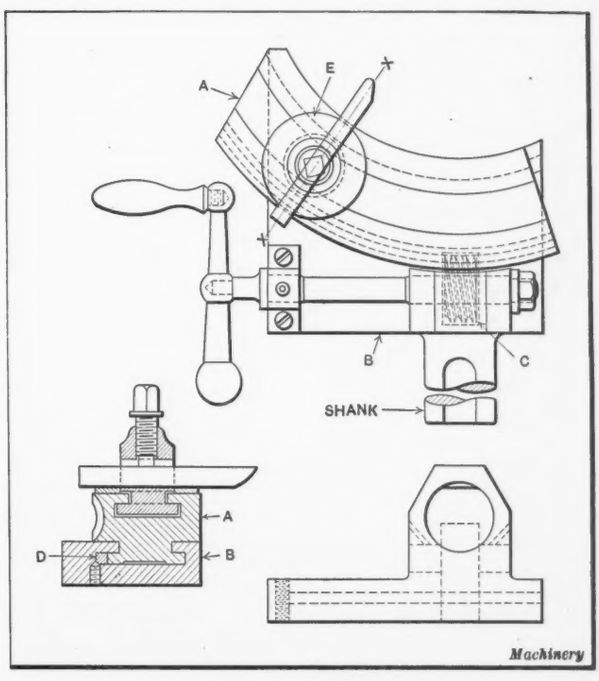
Two pieces of work *A* are set up in the string fixture on this machine, which is of relatively simple design. The two opposed spindles of the duplex machine provide for milling opposite faces of the work, each piece being clamped down in the fixture by means of a V-block *B*, which is forced down by tightening the bolt *C*. At the time the work comes to this machine, none of the surfaces have been finished, and so three suspension points are provided on each station of the fixture, one of which can be seen in contact with the casting at *D*. After the operator has set the second casting up in the fixture, he moves around to the back of the machine; and as soon as the first casting has passed out of engagement with the cutters, he releases the clamping bolt and removes this casting from the fixture. Then it is only necessary for him to remain idle during a short space of time while the cut is being completed on the second casting. As soon as this piece comes out from between the cutters, the operator removes it and goes back to the front of the machine to set up fresh castings for the next operation.

* * *

RADIUS-TURNING TOOL

By NORMAN McCLEOD

The accompanying illustration shows a tool which has been utilized on turret lathes for turning the half-ball joints used on locomotive steam and dry pipes. A tool of this design, however, could be used on other similar spherical turning jobs. A brief description of the device should be sufficient. The slide *A* moves in a T-slot in bracket *B*, the



Turret Tool for turning Spherical Work

shank of which is secured in the turret. This slide, in which the toolpost *E* is clamped, is operated through worm *C*, (which meshes with teeth cut in the slide) by means of a bellcrank handle. Adjusting screws and gib *D* afford means of adjustment to compensate for wear of the slide.

* * *

Iron ore is graded according to the percentage of phosphorus it contains. A low percentage of phosphorus—under 4½ per cent—makes it available for the Bessemer steel-making process, and such ore is called Bessemer ore. The non-Bessemer ore, which contains a higher percentage of phosphorus, is made into steel by the basic open-hearth process, which admits of the elimination of the phosphorus.

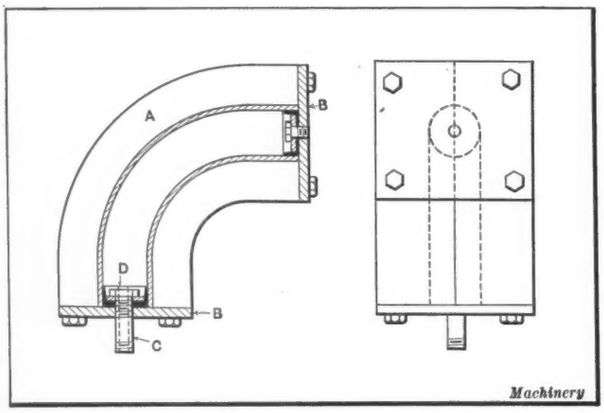


Fig. 1. Mold for expanding Bends

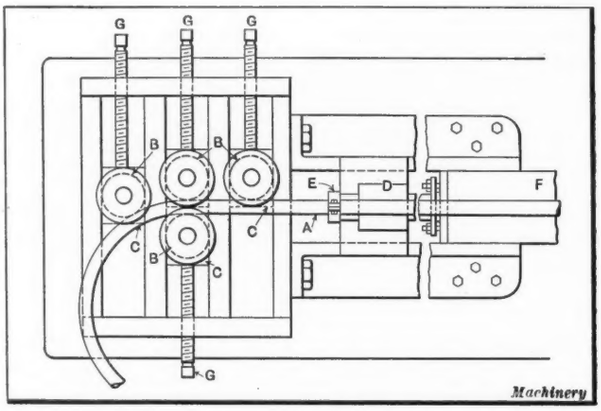


Fig. 2. Hydraulic Pipe Coiling Machine

Pipe Bending Machines

By R. P. DEANE

THE principles employed in bending pipe and the details of some of the machines used in making pipe bends, coils, plumbers' fittings, etc., from both iron and brass pipe and tubing, are dealt with in the present article. In most bending operations on smooth tubing, a device called a "ball mandrel" is used to keep the tube from collapsing. This is illustrated in the upper view, Fig. 3, in which *A* is the mandrel proper and *B* the balls linked to it, which straighten the wrinkles from the tube as it is bent. Rod *C* must be somewhat longer than the pipe before bending. Very short bends such as required in plumbers' supply elbows, offsets, traps, etc., cannot be made in one operation, for if they are kept from collapsing by the use of a ball mandrel the strain will break the tube. They are therefore allowed to collapse when bending. After being bent they are annealed in a gas furnace through which they are fed on a conveyor chain which allows them to drop in a pile to cool at the discharge end.

After annealing they are placed in the dies of a machine such as shown in the lower view, Fig. 3, called a "ball pusher." In this illustration, *A* represents the dies which hold the work. The lower die is bolted to the bed of the machine *B*, while the upper half is bolted to hinged lever *C*, the other end of which is operated by cam *D* on shaft *E*. Another cam *F* on the same shaft operates plunger *G* which pushes a row of steel balls through the partially collapsed bend clamped in the dies. The first one or two balls which enter the collapsed tube are the exact size of the inside of the tube, while the others are a little smaller and act simply as pushers. The machine is set on a slight angle so that the smaller balls roll back by gravity as the plunger returns to its starting point. Of course, the full-size balls will not roll back through the bend, but will roll back through the die when the tube is removed. Some of the bends used in cash carrier systems are required to have a greater inside diameter than the straight sections in order to allow the cash box to pass around the bend. These bends are expanded after bending by hydraulic pressure while the bend is held in a die or mold of the required shape such as shown in Fig. 1. The ends of the tube are closed by cup packings which are prevented from being blown out by plates *B* on the ends of the mold. The water is admitted by nipple *C* which passes through the packing and is held by lock-nut *D* and a washer as shown.

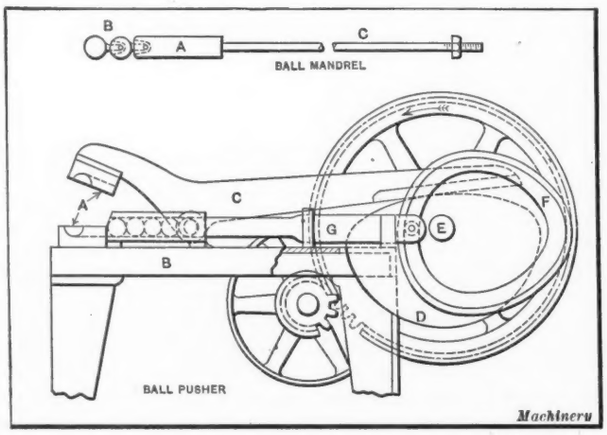


Fig. 3. (Upper View). Ball Mandrel employed to prevent Tubes from collapsing during Bending Operation. (Lower View). Machine of the Ball Pusher Type employed to expand Tubes which have been permitted to collapse during the Bending Operation

Making Pipe Coils

In making coils the radius is not so short and the pipe is usually heavier; therefore no great difficulty is experienced from collapsing of the tube. Coils are usually made with no mandrel inside, and unless very small, no filling is used. They are made by two methods, one of which is illustrated in Fig. 2. When in operation the machine forces the pipe *A* between formed rollers *B* which are held on sliding blocks *C*, the latter being held in position by adjusting screws *G*. The formed rollers can be changed to fit any size pipe, and the position of the last roller governs the radius to be bent. The pipe is forced through the grooves on the rollers by a hydraulic carriage *D*. A collar *E* is clamped to the pipe which is moved back on the pipe after each stroke of the carriage. The pipe is rolled or rotated slightly to give the coil the required pitch. The hydraulic cylinder *F* is below the center line of rollers *B* so that the pipe passes over it.

Some iron pipe coils have to be bent hot, in which case the coiling machine draws the pipe through a long gas furnace which heats it as fast as it is drawn through, the machine, of course, being set close to one end of the furnace. Coils of this nature often require several hundred feet of pipe. The pipe is usually welded on an electric butt welding machine although some are welded by hand, the welding being done before coiling. Flat spiral coils are made on the machine shown in Fig. 2, by changing the adjustment of the rolls as the pipe is forced through. Coils are also made on a machine called a "swiper" which is shown in Fig. 4. In this machine, a former *A* the size of the inside of the coil is driven by a central shaft *B*, which is driven by a worm *G* and worm-wheel *C*. The end of the pipe is clamped to the former by clamp *D*, and after about a half revolution the clamp is loosened and the machine reversed so that the clamp can obtain a new

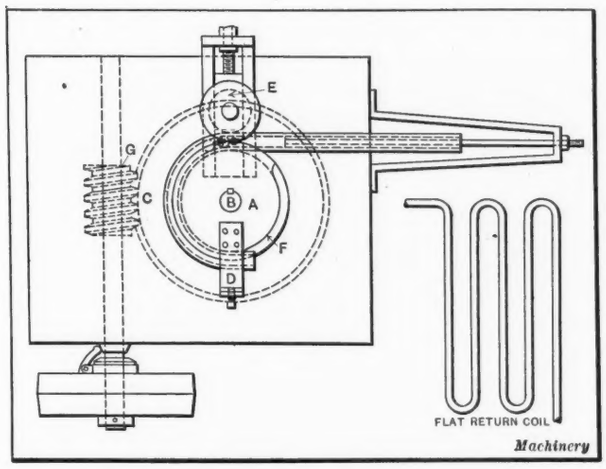


Fig. 4. Type of Bending and Coiling Machine commonly termed a Swiper

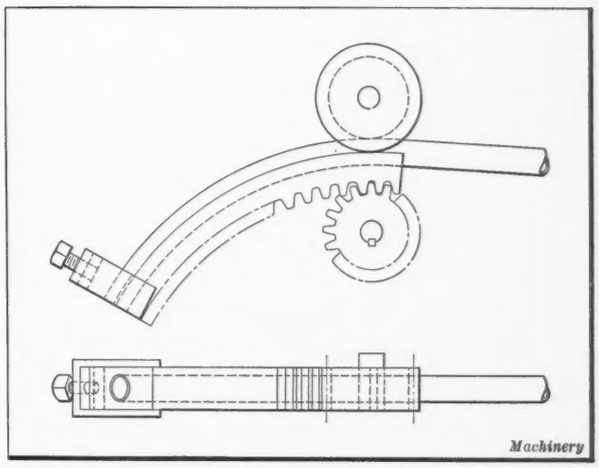


Fig. 5. Former and Driving Pinion used in making Bends of Large Radius

grip on the pipe. The pipe is also turned or revolved slightly each time in order to give the proper pitch to the coil. The pipe is held against the former by a follower roll *E* or sometimes by a formed block. The top flange of the former is cut away beyond the clamp at *F* to allow the pipe to be raised to form the pitch of the coil.

Flat return coils like the one shown in Fig. 4 are made on machines of this type, the pipe being bent before welding. As many bends as possible are made from each length of pipe, the first bend in each succeeding length being made the proper distance from the end to match the preceding one. They are then welded on the electric welder. This type of machine is also used to make the most simple bends and is often used in connection with ball mandrels. The rod on the mandrel must be longer than the pipe before bending, as the pipe is slipped over the rod and mandrel and drawn off as bent. As the end of the mandrel is located at the point of bending, the balls are allowed to swing around the bend, thus ironing out the wrinkles. The end of the rod must be attached very firmly, the means of attaching depending on the length of pipe and other conditions.

When making bends having a longer radius than can be swung from the central shaft, the former is replaced by a coarse-pitch pinion gear and a former such as shown in Fig. 5. As will be seen, this former has rack teeth on the inside. The guide roller keeps the teeth in mesh with the pinion. By this method, bends of any radius can be made on a machine of the same strength and power as required for small bends.

Machines Employed in Bending Large Pipe

The bending of large pipe is accomplished by quite different methods and on an entirely different machine, as will be seen by referring to Fig. 6 which shows one of the types commonly employed. These machines are built of I-beams *A* having large V-shaped rolls *B* and *C* attached as shown, which support the pipe *D*. *E* is an adjustable bracket which is clamped to the I-beams at the proper height to produce a bend of the required radius. This bracket carries a radius-bar *F*, the end of which hooks to a clamp on the end of the pipe. At *G* is a circular gas burner carrying two or four blast nozzles, according to the size of the pipe. The inside of the burner is lined with fireclay. These burners heat only a very small section of the pipe at a time so that it cannot collapse. In operation, streams of water are played on the pipe on each side of the burner to keep the heat from spreading. Pressure is applied to the end of the pipe for medium sized work by a chain arrangement operated by a chain hoist, not shown. This hoist is equipped with a ratchet and pawl which replaces the hand chain sprocket, the pawl being connected to a crank on a countershaft. The lift chain runs over idlers on the frame and around one end of the pipe as shown.

As the chain is tightened the pipe is forced through the gas burner, but since the other end is attached to the radius-bar it must bend to a radius equal to the distance from the center of bracket *E* to the center of pipe plus some "spring back." As only a few inches length of the pipe is hot, it cannot collapse any appreciable amount, and as fast as the chain pulls the pipe through the burner it is heated and bent. For the largest sizes of pipe, the roll *C* is replaced by a long I-beam bed carrying the ratchet rack and hydraulic creeper shown in Fig. 7, in which pawl *A* pushes along one notch which is held by pawl *B*, while *A* reverses and engages another notch. This device has been used to bend pipe 24 and 30 inches in diameter. Large bends sometimes must be rectified to make up for the spring back or errors in measuring angles on the machine. This is done on large floor-plates provided with holes for stakes so that blocking may be used to hold the pipe in the proper position. After being fastened in place, the pipe is sprung with chains and hoists so attached as to pull in the proper

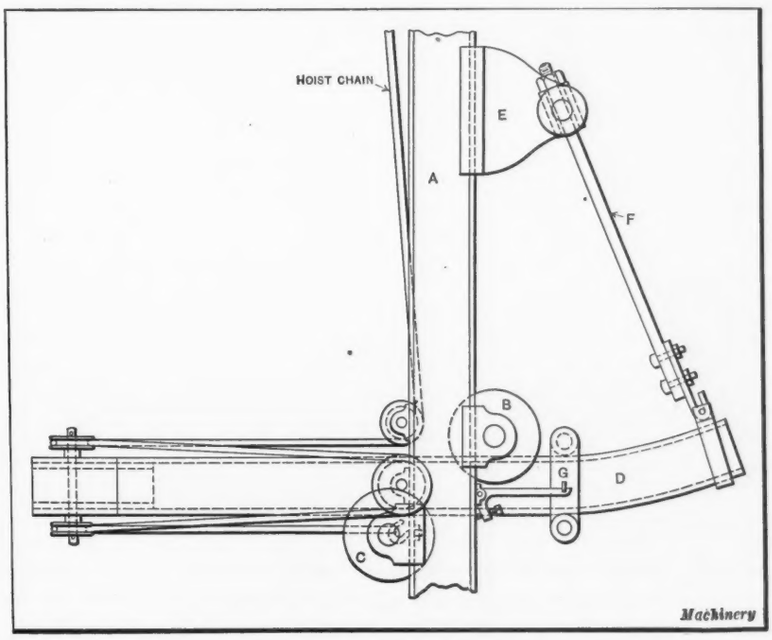


Fig. 6. Machine used for bending Pipe of Large Diameter

direction while the pipe is being reheated with circular burners of the same type as is used on the machine. When the bend must be made close to the end of the pipe it is usually flanged before bending and a short piece of pipe bolted on, to which the radius-bar is attached, thus giving the machine more leverage.

Some bends of large radius are threaded for screwed flanges on a machine with a revolving die-head, this operation being usually done after bending. Other bends are flanged for the "Van Stone" system of joint. For this work, the end of the pipe is heated and clamped in a ring or form

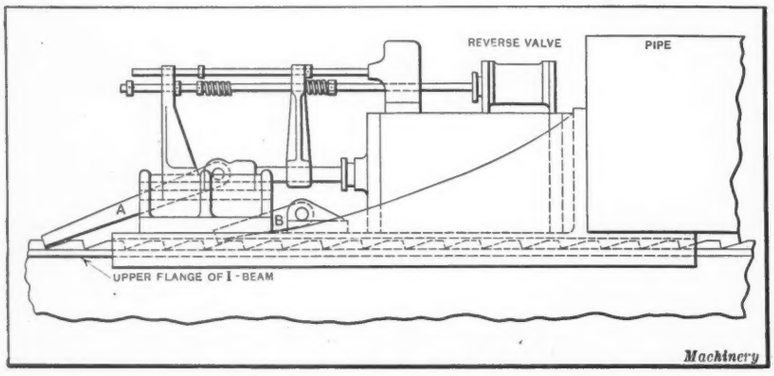


Fig. 7. Hydraulic Creeper mounted on I-beam Bed, which is used in Place of the Chain Feed shown in Fig. 6 when bending Pipes of the Largest Size

allowing enough pipe to project to make the flange. A revolving head located close to the clamp carries a slide provided with a roller which rolls the flange over the face of the clamp. This slide is fed out by a screw and star feed. The big bending machines always have a pit in front to facilitate the handling of offsets, expansion bends, etc. Bends of a radius equal to three times the diameter of the pipe or larger are made with good results on these machines. The writer has seen bends of even shorter radii made; but three times the diameter or larger is the usual rule.

* * *

JAPAN'S INDUSTRIAL EXPANSION

According to a recent Commerce Report, the industrial progress of Japan which has been especially rapid during the period of the war, has been promoted to a large degree by the introduction of American and other foreign machinery. In changing from ancient to modern methods, almost every type of machinery perfected in foreign countries has been imported by Japan. An idea of the increasing market for machinery may be obtained from the value of machinery imported into Japan within the past five years which shows that in 1914 the imports amounted to $12,471,182 as compared with that of $29,248,999 in 1918. It is interesting to note that in 1914 only 20 per cent of the machinery imported by Japan came from the United States, while tables compiled by the Commerce Department show that 80 per cent of the machinery imported by Japan in 1918 came from the United States. As a result of these extensive imports, the manufacture of various types of machinery has increased quite rapidly in Japan so that the value of the machinery exported by Japan during the year 1918 amounted to $7,898,268 as against $634,483 in 1914. Statistics show that practically all the machinery exported was sold in the Far Eastern countries although they indicate that an effort was made in 1918 to establish a market for Japanese machinery in South America.

* * *

Casein glues are exceedingly resistant to the action of water, and retain a high percentage of their original strength even after long immersion under water. Waterproof glues have been developed primarily for aircraft purposes. Information on casein glues and their application may be obtained from the Forest Products Laboratory of the United States Forest Service, Madison, Wis.

WHEN MACHINERY MUST BE GUARDED

By CHESLA C. SHERLOCK

For many years the law has recognized the danger of moving machinery and sought to lessen it by proper legislation, requiring an employer to provide safeguards for his machinery where that machinery was dangerous to the persons employed. The law did not impose this duty as an alternative to the relief afforded by the common law or even as an alternative to the relief afforded by the compensation acts. It imposed the duty to safeguard machinery independently and in addition to such liability as might fall upon the employer *after* the accident had occurred.

When Must Employers Install Safeguards?

The question naturally comes to the mind of every employer who uses machinery in his business: "When must I install safeguards; what are the safeguards mentioned by the statute; what appliances in my shop or factory should be classed as dangerous machinery within the meaning of the law?" Perhaps the matter might be stated with a little more clearness by asking this question: "When is there a legal necessity for safeguarding machinery?" All machinery, tools or appliances are evidently not dangerous within the meaning of the statute; nor are all dangerous agencies employed in the average shop or factory "machines or appliances" within the meaning of the law. Then, when must the employer provide safeguards in order to comply with the rules laid down by the statute? There is only one answer. It is not found in reading the statutes, but in the decisions handed down by the respective courts which have been called upon to deal with this matter. These decisions are conclusive where they cite specific instances regarding the kind of machinery under consideration. It is by these decisions, and by these decisions only, that the employer should be guided. They give him the advantage of a rule used by the courts in deciding questions relative to a specific type of machinery. With these rules he may judge the meaning of the statute in question.

For instance, in Indiana there is a statute which requires employers to safeguard machinery. It is shown in a case decided by the court of that state that a certain employer had an open space in his floor, and underneath this open space revolving machinery containing knives and rollers. The employer in this case failed to safeguard this place and legal action was brought against him under the statute. The court held that he was not liable, inasmuch as this opening in the floor could not be considered within the statute requiring him to safeguard his machinery, because a hole in a floor was not deemed to be, in a legal sense, a machine, a tool or an appliance.

Kind of Safeguards Required

It has been pointed out in so many cases that it has come to be generally understood that the employer is not required to provide the best safeguards, or the most complete safeguard, or the latest on the market. There may even be a new safety appliance on the market which entirely revolutionizes the old ones, but it is not necessary, under the decisions, for the employer to discard the old ones for the new, because the law requires nothing unreasonable of the employer. He is only required to use such precautions as reasonably prudent men in the same business employ. In doing this he fulfills the purpose of the law, provided he acts in good faith. No employer is excused from liability by any plea when it was plainly his intention to evade the law.

In both Minnesota and Indiana it has been said that mere inconvenience will not excuse an employer from using the safeguards required by law. In the latter state it was said that a 1500-pound hammer, used in crushing car wheels be-

fore melting them, was a machine within the meaning of the law and that it must be safeguarded in the manner provided, even though it proved inconvenient to do so.

When a Law Becomes Effective

Employers often contend that they are not liable under the safety appliance acts because they have not been notified by the state factory inspector to make installation of appliances intended to safeguard the workmen, but the fact that the state factory inspector has made no objection to the methods or lack of methods used by any employer does not lessen his liability. The law is notice to everyone the minute it is written into the statute books and it becomes immediately effective, provided it has been duly enacted.

In an Illinois case an employe was injured by a machine as a result of being pushed by another employe. The employe, in trying to save himself from falling on a moving belt, put his hand into his machine which contained moving knives. As a result he lost three fingers. The employer in this case contended that he was not liable under the statute because the state factory inspector had not given him notice to put a guard over the knives in that particular machine. The court said that the statute imposed an absolute duty upon the employer to safeguard that machine regardless of what the factory inspector might have said.

Personal Liability of Employer

In Washington it was said that friction wheels were within the meaning of the statute of that state and that they must be guarded, while in Indiana it was said that they came within the provision relating to gearing. In Minnesota it was held that a traveling screw in a conveyor box, used for moving grain from one part of an elevator to another, was a dangerous machine and that under the statute it must be guarded in order to prevent injury to workmen who might come in contact with it. In another Minnesota case where a workman on a ditching machine injured his foot by stepping into an unguarded bevel gear, it was held that the employer was not excused from liability merely because he had directed other employes to put a cover over the gears, and they had failed to do so. In this connection it might be noted that it is the settled rule of law practically all over the country that the duty imposed by the statute is a personal one and one which cannot be delegated to another person. The employer is the person directly charged with the responsibility of safeguarding machinery, and if he were permitted to delegate his duty to another he could readily escape liability in nearly every case by claiming that the responsibility had been transferred to a subordinate.

Injuries Caused by Materials in the Process of Manufacture

In a Washington case a distinction between machines and their products was noted which is of great importance to the employer when considering the extent of his liabilities. It was held that the statute, while it applied to the machine itself, did not apply to the material fed into the machine. In other words, under the ordinary safety appliance act there is no duty imposed upon the employer to take means to guard the employe from accidents caused by the material which is fed into the machine. Fully half of the accidents occurring in the average factory and shop are caused by the material. However, another point should be brought up in this connection. The mere fact that an employe is injured by a piece of material while feeding it into the machine does not excuse the employer from liability in all cases, but merely from liability under the safety appliance acts. Where the workmen's compensation acts are in force, another liability for the accident is imposed entirely independent of the cause of the injury.

In Wisconsin it was said that the mere fact that a machine caused injury to an employe was insufficient to show that it was a dangerous piece of machinery within the meaning of the safety appliance acts. In another state it has been held that any machine operated by hand is not required to be guarded, as it is not considered dangerous, but in Indiana it was held that a crane operated by hand must be safeguarded. It has been pointed out in other cases that the mere fact that a dangerous situation is created when a machine is operated in a careless manner does not in itself bring the machine within the class required to be safeguarded by the statute.

In Minnesota it was said that the actual question as to whether a machine is of such a dangerous type as to require safeguarding under the statute, is one for the jury to decide. This seems to be the case in most of the states, as it nearly always amounts to a question of fact. In Michigan it was said that the factory inspector's decision as to whether a machine is dangerous is not always conclusive. This decision was reached in the case where a workman tripped on a belt lying on the floor and caught his hand in the gearing of the machinery.

When Guards Interfere with Practical Operation of Machine

As showing the common sense trend of the decisions, employers can note with satisfaction that it has been held in a large number of cases that the test of a safeguard is its practicability. If the measures which are necessary to safeguard the machine properly are such that they destroy its practical value in the factory or shop, it is held, in Indiana, Maryland and a number of other states, that the safety appliance act is inapplicable. This decision is based on the fact that it is not the intention of the statutes to interfere with the practical operation of machinery. In Minnesota, as well as in Washington, it was held that the question of whether or not the appliance for safeguarding is practical, was one to be decided by the jury. Where questions arise as to the necessity of safeguarding internal portions of machinery, particularly that relating to gearing and as to whether a sufficient guard is presented by the frame of the machine itself, it is generally held to be a question for the jury. In a New York case it was shown that a machine had a space of about 4 inches between a partition and revolving disks. While attempting to clean the revolving disks the operator was injured. The court held that in this case the employer was not liable for failing to safeguard the disks.

Summary

From the preceding it seems that the employer must guard his machinery under the following conditions:

1. When it is expressly required by statute; that is, when certain kinds of machinery are expressly named in the statute itself.
2. When this machinery is dangerous to the life and limb of workmen under normal and careful operation; or where it is plainly evident that the machine should have been included in the enumerated list of the statute, but was apparently overlooked. Where there is no list given in the statute, the employer can only have discharged his duty when he has safeguarded all dangerous machines or appliances as a reasonably cautious man in the same profession, trade, or calling would have done.

* * *

According to a recent Commerce Report, there is a movement on foot in Germany to organize the automobile manufacturers into what appears to be a cartel similar in form to the German Dye Syndicate. The object of this organization would be to diminish cost of sales and to bring into operation an agreement whereby each factory would limit the number of types which it made. The first results of this movement have been the establishment of the Gemeinschaft Deutscher Automobilfabriken (Association of German Automobile Manufacturers), by the National Automobil Gesellschaft, the Hansa-Lloyd Werke, A. G. Bremen and the Brennaborwerke at Brandenburg. These three concerns have made an agreement covering their manufacturing program, and are said to have agreed also to have their local sales conducted jointly.

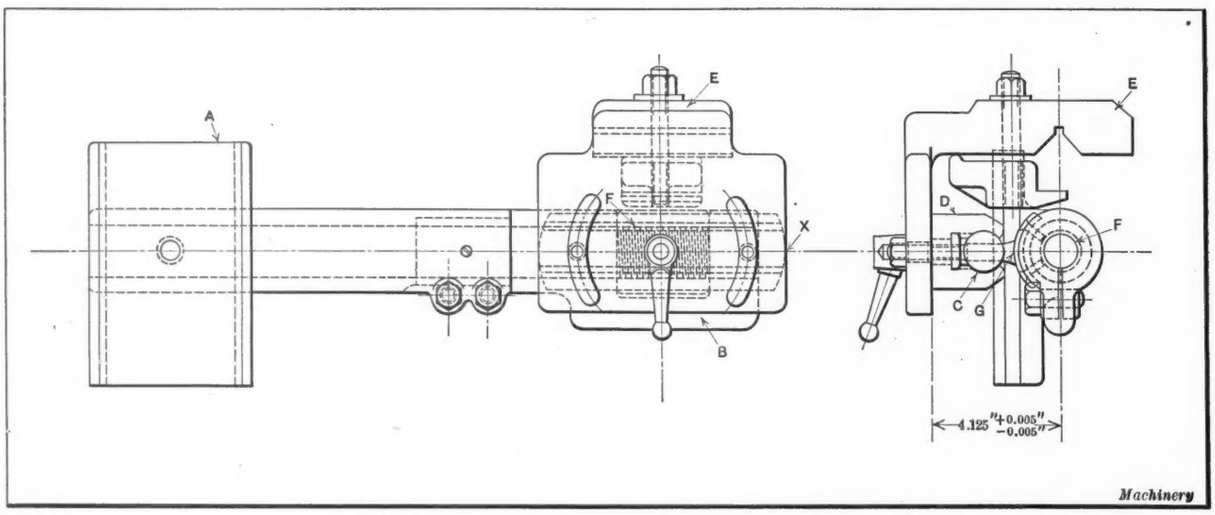
PITCH COMPENSATOR FOR THREAD-CUTTING LATHES

By J. B. CONWAY

The illustration accompanying this article shows the assembly of a device for compensating the error in the lead-screw of a lathe when cutting threads. It is well known that the ordinary commercial lead-screw is not intended to be sufficiently accurate for cutting precision threads. It is also known that the cost of manufacturing a lead-screw which is suitable for this type of work is almost prohibitive for general use. When making fine instruments and gages, even a minute variation in the lead of the thread must be avoided, and to this end the compensator here described was designed for use in the Gage Division of the Frankford Arsenal. Other lead-screw pitch compensators have appeared on the market from time to time, and while they all follow the same fundamental principle, the construction of each is different. The principle involved in this design is also used by the Pratt & Whitney Co., Hartford, Conn., and by the Greenfield Tap & Die Corporation, Greenfield, Mass.

The design consists essentially of a carrier block *A*, an extension arm and nut retainer *B*, roller *C*, roller guide *D*, roller guide support *E*, compensating nut *F*, compensating nut stem *G*, besides the miscellaneous details. The carrier block *A* is made of cast iron and is fitted to the apron slide, the split nut on the lead-screw and the cam which operates it being removed for this purpose. Provision is made for bolting the carrier block securely in place, utilizing the cam bolt hole. The extension arm *B* is made separate to allow it to be replaced by arms of various lengths as occasion requires. The compensating nut *F* is made of bronze and is fitted to the lead-screw of the lathe to which the device is to be applied. It is supported by the extension arm and is free to turn upon the lead-screw. The compensator nut stem *G* is fastened to the compensator nut and carries the roller *C* which is free to slide on the stem. The roller guide *D* has a circular groove extending its full length in which the roller slides as the nut travels laterally. The guide is pivotally clamped to the roller guide support *E*, which is clamped to the ways of the lathe.

With the attachment in place, it is only necessary to adjust the position of the roller guide as determined by the arc-shaped slots in the roller guide support, so as to shorten or lengthen the travel of the carriage in relation to that of the compensator nut. The studs projecting through the slots are provided with a clamping handle. The movement of the lead-screw imparts motion to the nut, which in turn actuates the apron and the carriage. If the error in lead is assumed to be +0.005 inch in 3 inches, this can be compensated for by swinging the end of the roller guide upward sufficiently to shorten the lateral travel of the carriage 0.005 inch during the 3-inch travel of the nut. The end of the roller guide and its support is graduated (the zero line being at *X*) in order to facilitate the setting, but this must be established after the attachment has been tried out and the existing error in the linear pitch of the lead-screw determined. This attachment may, of course, be used in the neutral or central position, the same as with the ordinary split nut. It cannot be disengaged, however, unless it is removed from the lathe, which can be readily accomplished by removing the supporting bracket at the end of the lead-screw, thus allowing the device to be easily disassembled.



Assembled View of Compensator for Errors in Pitch of Lead-screws

* * *

RESEARCH IN ALLOYS

The Division of Industrial Research of the National Research Council is arranging for the formation of a cooperative association to plan and support fundamental researches in alloys. Although much valuable work has been done in this field by scattered investigators, there is no doubt that a well-planned and coordinated effort by a cooperative association working under the general guidance of the National Research Council and composed of specialists representing both the manufacturers and the more extensive users of alloys can produce additional results of great importance. The success of other industries which have supported research on a cooperative plan, such as has been done by the National Canners' Association and the Malleable Iron Manufacturers, is evidence of this. It is planned to create a special scientific staff composed of a director and assistant director of research and a group of scientific investigators and technical experts who will give their whole time to the work. To finance the organization, each member of the cooperative association will pay $1000 a year, and all contributing members, who may be either alloy manufacturers or users (individuals or companies) are to benefit alike by the results of the researches.

* * *

A new method for regulating the heat in an electric furnace has been developed by Walter P. White and L. H. Adams, of Washington, D. C. By making the heating coil of the electric furnace one arm of a Wheatstone bridge, the inventors have succeeded in keeping the temperature of a laboratory electric furnace constant, for hours, within 0.1 degree C., at temperatures between 500 and 1400 degrees C., and this practically without any attendance. Previous to this development, a regulation within 5 degrees C. was considered good. The present arrangement appears to be limited to direct currents.

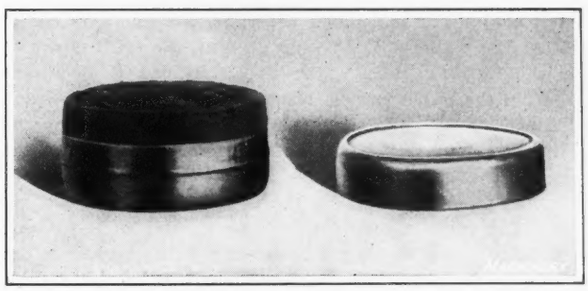
LETTERS ON PRACTICAL SUBJECTS

WE PAY ONLY FOR ARTICLES PUBLISHED EXCLUSIVELY IN MACHINERY

LUBRICATING DEVICE FOR SMALL TOOLS AND INSTRUMENTS

Squares, rules, protractors, and other similar steel graduated tools, if not properly cared for, soon acquire a slight coating of rust caused by handling or by atmospheric conditions. The result is that it becomes difficult to read the graduations and makes it necessary to polish the tools frequently. As the graduations are not very deep, this scouring, especially if abrasives are used, may in time obliterate the markings and thus destroy the usefulness of the tool.

The writer has devised the lubricating device illustrated herewith, which may be inexpensively made and which, if regularly used, will prevent the accumulation of rust, and consequently preserve the life and usefulness of the tools. The lubricator consists simply of a small tin ointment box procured for a few cents at almost any drug store, in which is inserted a roll of felt. The felt should be of the proper width so that the cover may be easily put in place after the roll has been wound to tightly fit the box. A small bottle of vaseline costing about 5 cents should be purchased and the contents applied to both sides of the felt before it is rolled up. The felt might be saturated with lubricating oil instead of vaseline, but oil usually contains traces of acid, the action of which will tarnish the steel surface. Vaseline,



Lubricator with Cover removed, showing Roll of Felt

being a petroleum product, keeps the surfaces bright and free from rust. Steel tools should be greased every day before going home from work. The cover should be kept on the box at all times, except when in use, so as to exclude dust from the felt.

Youngstown, Ohio W. S. STANDIFORD

DEVELOPMENT OF TIME SLIDE-RULE

The diagrams shown in connection with this article illustrate three different methods by which the time required to complete a job may be instantly found if the starting time and the finishing time are known. Each idea originated from a different source in the shop, the slide-rule shown in Fig. 3 being the final and best scheme devised.

Fig. 1 represents the first idea—that of a chart for calculating elapsed time. In changing over from a system of figuring time in which hours and minutes are used, to a system calculating in tenths of an hour and hundredths of a minute, some trouble was experienced by the time clerks. Ordinarily this change would have been easily handled, but at the time that the change was made, the jobs were short, one man often having several job tickets per day. This frequent changing of tickets and the computation involved, caused confusion and errors which resulted in the design of the chart and subsequently of the slide-rule.

From the point representing the starting time, at the top of chart, follow the corresponding diagonal downward until it intersects the vertical line corresponding to the finishing

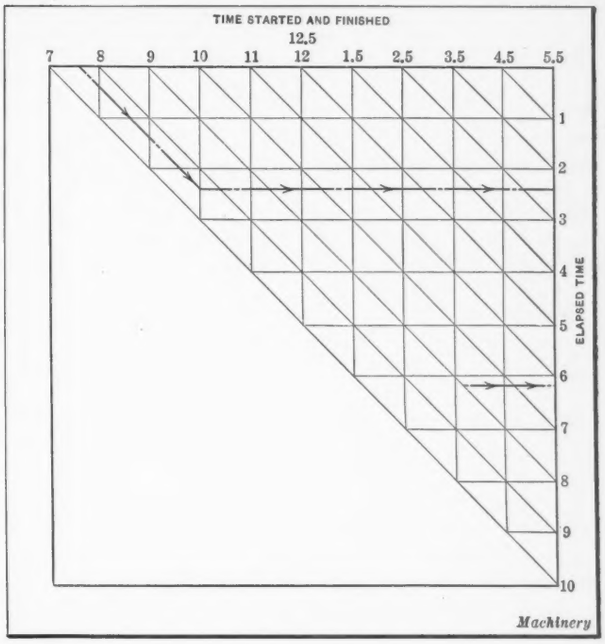


Fig. 1. Chart for finding Elapsed Time when Starting and Finishing Times are known

time, and thence along the horizontal line to the right-hand side of the chart where the elapsed time can be read. For instance, if the starting time is 7.6, that is 7:36 A. M., and the finishing time 10 A. M., the reading at the right is 2.4 hours; or, if the starting time is 9 A. M. and the finishing time 3.7 or 3:42 P. M., the elapsed time will be 6. 2 hours The main divisions of the chart should, of course, be divided into ten subdivisions when the time is figured by tenths of hours, whereas if the time is figured by minutes, there should be sixty divisions, which would require a large chart.

For the benefit of those who desire to construct a chart, the following explanation is offered. Lay off on the horizontal axis a number of divisions equal to the working

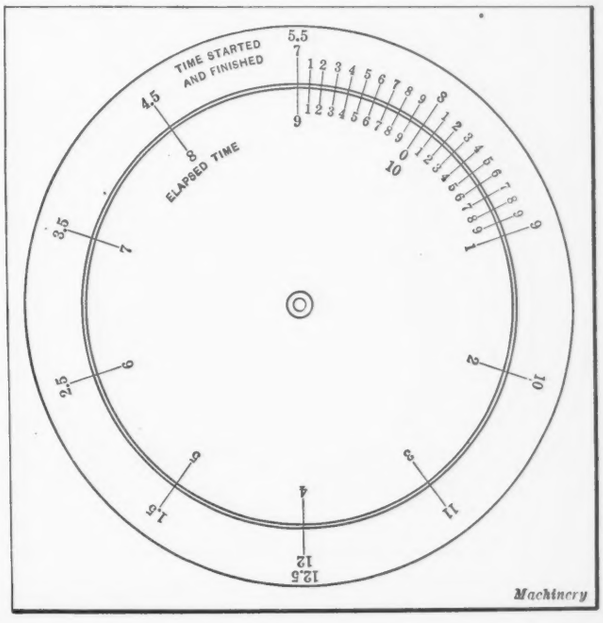


Fig. 2. Circular Slide-rule, the Use of which is Identical with that of the Chart

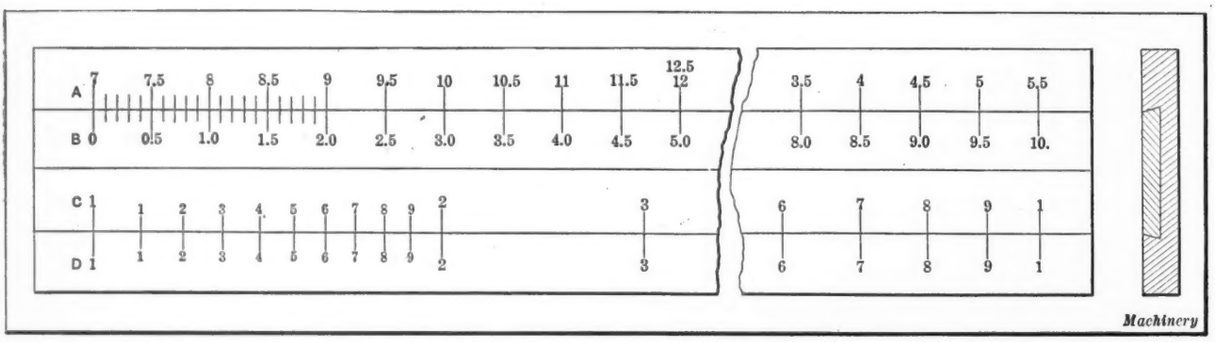


Fig. 3. Slide-rule Arrangement by Means of which Elapsed Time may be found. Arithmetical Operations may be performed on the Lower Scales

hours in the day, as for instance, ten. Mark the left end of the line as the starting time, or 7 o'clock, and each of the divisions to represent one hour, that is, 8, 9, and so on up to the lunch hour, or 12 o'clock. As the lunch hour must be deducted from the time included between start and end of the working day, the starting time after lunch will begin at the same point at which the quitting time is registered. The next division after the lunch hour will be marked to represent an elapse of one hour from the time of the start of the afternoon work, in this case, 1.5 or 1:30 P. M. Continue thus, to the time for quitting. Draw a vertical line of the same length as the horizontal axis at the right-hand side of the chart and divide it into ten equal parts numbering the divisions as shown in the diagram, to correspond with the number of hours in the working day. Diagonals are then drawn connecting the division marks on the two axes, and the horizontal and vertical lines drawn as shown.

Fig. 2 represents simply a circular slide-rule constructed from the chart, consisting of two circular disks, pivoted at the center so that the inner disk may revolve within the other. The numbers designating time and hours elapsed are identical with those used on the chart and the results obtained are exactly the same. The straight slide-rule, Fig. 3, is evidently the best arrangement for obtaining the elapsed time, and in addition, contains on the lower part of the rule a reproduction of scales *C* and *D* of a standard 10-inch slide-rule, thus enabling the calculations connected with time-keeping to be performed directly on the rule. The material used should be seasoned wood, preferably cherry or walnut, and care should be exercised to obtain a nice working fit where the slide is dovetailed in the body of the rule.

Camden, N. J. J. B. CONWAY

DIES FOR DRAWING AN AIR PUMP PART

In the manufacture of a combination piston and cylinder furnished in an air pump used for pumping up automobile tires, the dies described in the following article are required. The pump is attached to one of the spark plug holes of an automobile engine while in use. The various dies that are employed in producing this part are illustrated in the order in which they are used, and the dimensions of the shell after each operation are also given.

The shell is made from cold-rolled strip steel, 0.065 inch thick, the blank being 5 13/16 inches in diameter. The die shown in Fig. 1 is a combined blanking and drawing die which cuts the blank and performs the first forming operation. This die is of the standard type and is used on a press having the usual rubber buffer attachment and plates for pins *A*. The steel strip is laid upon the cutting ring *B*, and as the edge of the punch face ring *C* passes the edge of the cutting ring when the punch descends, the blank is cut to size. As the punch continues its descent, the shell is drawn upon the forming die *D*. The knock-out pad *F* ejects the shell from the punch on the return stroke of the press ram.

A reduction is made in the diameter of the shell by the die illustrated in Fig. 2 which also commences to form the flange. When ring *A* is in the normal position, the upper end of the ring is flush with the upper end of the forming die *B*. The shell is placed over ring *A*, and as the punch descends, the ring is pushed downward until it reaches the position shown, at which point this operation upon the shell has been completed. The pins *C* push the ring *A* back to its original position upon the return stroke of the press ram and at the same time force the shell from the forming die.

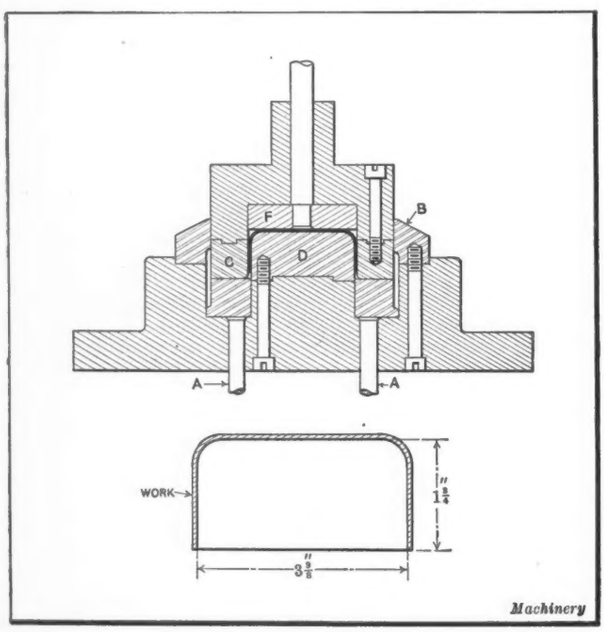


Fig. 1. Combination Blanking and Forming Die for performing First Operation on Shell

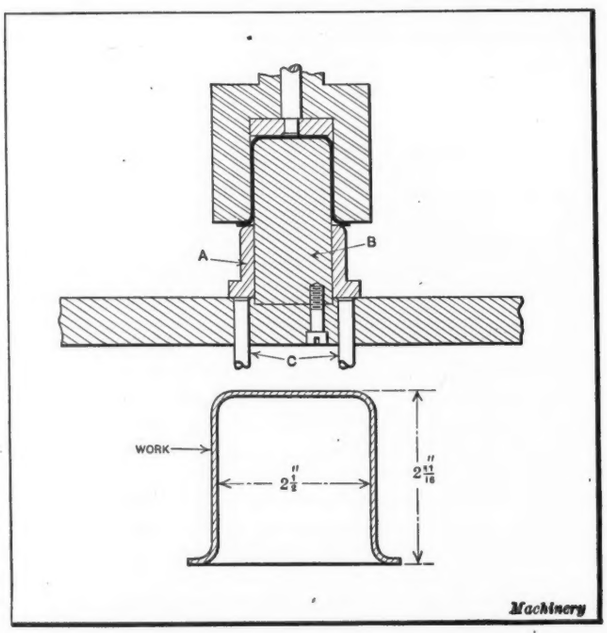


Fig. 2. Die employed to reduce the Diameter of the Shell and start forming Flange

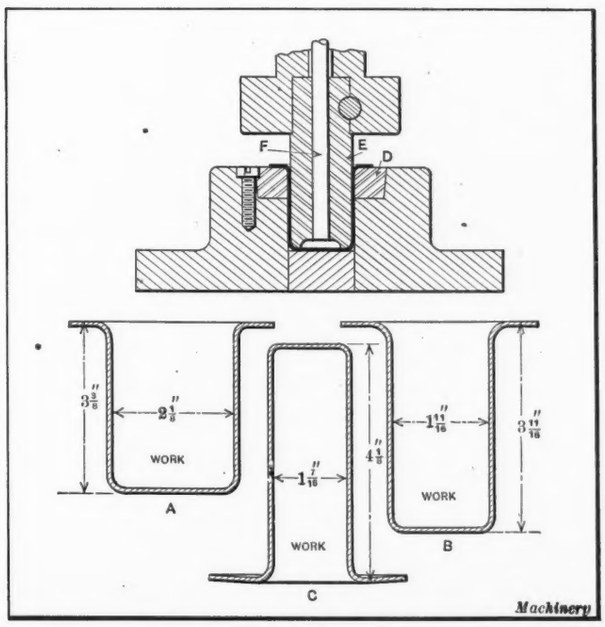


Fig. 3. Type of Die used to make Three More Reductions of the Diameter of the Shell

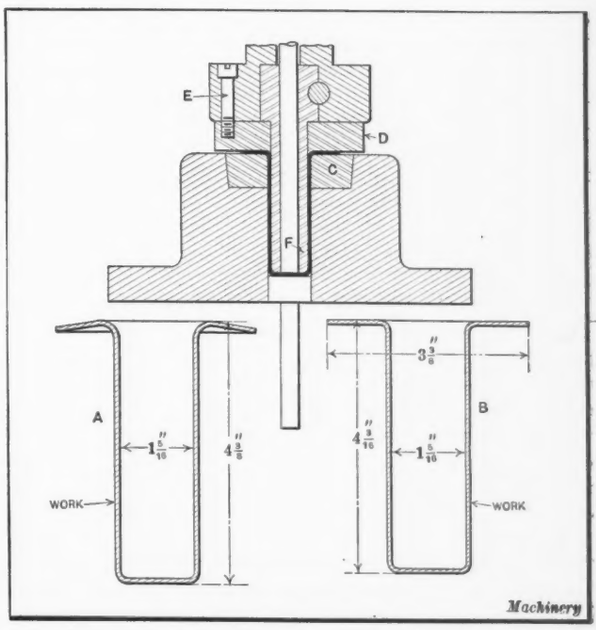


Fig. 4. Die which makes the Final Reduction of the Shell Diameter and flattens the Flange

Three different sizes of dies of the construction shown in Fig. 3 are used to further reduce the diameter of the shell. The shell is first reduced to the size shown at *A*, then to the size shown at *B*, and finally to the size shown at *C*. In each case the shell is forced into the die only until the flange comes in contact with the forming die *D*. If an attempt were made to draw the shell any deeper, the bottom would be forced out, because the flange cannot be reduced at the same time as the body. The punch *E* is inserted and held in the press in such a manner that it is not pushed from the press when the rod *F* forces the shell off the punch.

Fig. 4 shows the die that makes the final reduction in the diameter of the shell to the dimensions shown at *A*, and also flattens the flange as shown at *B*. Two operations are performed to attain this end. When the shell is being formed to the shape illustrated at *A*, the ring *D* and screws *E* are removed from the punch. As in the preceding dies, the shell is forced into the die only until the flange touches the die-ring *C*. After a certain quantity of shells has been drawn to the shape shown at *A*, the ring *D* is secured in place as shown and a second operation is performed upon the same pieces, flattening the flange as shown at *B*. The die illustrated in Fig. 5 trims the flange of the shell and cuts a hole in the opposite end. The flange is trimmed as the cutting ring *A* passes the edge of ring *B* on the downward stroke of the press ram, the scrap being forced down on the cutter *C* which cuts the scrap into two pieces, permitting it to fall away from the die. The hole is cut in the end of the shell as the face of punch *D* passes the edge of the cutting ring *E*. A detail of the knock-out pad *F* is shown at *G*.

The final operation on the shell consists of "edging up" the flange by the die shown in Fig. 6. When ring *A* is in the normal position, the upper face is on a level with the upper surface of the die-ring *C*. The shell is then placed on plug *B* and ring *A* and as the punch descends the edge of the flange is forced back and the face is flattened. The plug *B* is 0.007 inch larger in diameter than the punch *F* in Fig. 4 which makes the final reduction in the shell diameter. This increased size permits the barrel of the shell to be expanded at certain points and upset at other points, thus causing the sides of the barrel to become parallel. After the operation has been performed, the shell is forced from plug *B* by means

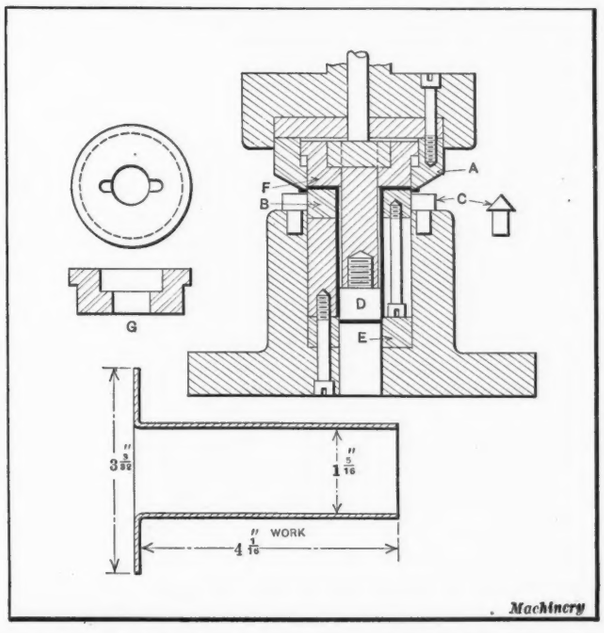


Fig. 5. Method of trimming the Flange and cutting the Hole in the End of the Shell

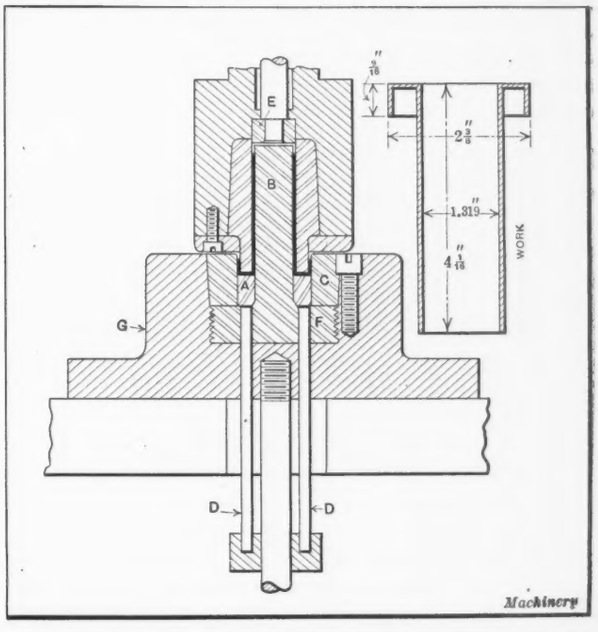


Fig. 6. Die for performing Final Operation which consists of edging up the Flange

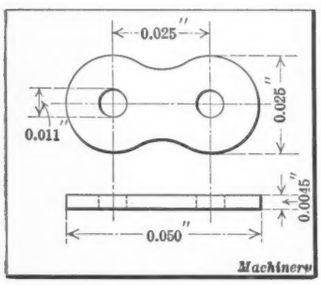
of the pins *D* which force the ring *A* upward, while the knock-out pad *E* ejects the shell from the punch. The tool-steel plug *F* which is screwed into the die-block *G* serves as a bumping block for ring *A* and as a guide for pins *D*. All parts of the different dies are hardened and ground.

The dies described were made while the writer was superintendent at the Acklin Stamping Co., Toledo, Ohio.

Toledo, Ohio J. BINGHAM

FLAT-LINK CHAIN OF MINUTE PROPORTIONS

A flat-link chain has been found to be the best medium for transmitting the motion of an altimeter diaphragm to the indicating hand. It is evident that the chain for such a sensitive instrument must be exceedingly small as compared with the usual machine shop dimensions. Previous to the outbreak of the war, this chain was obtained from Swiss manufacturers, but owing to the fact that the war both increased the demand and cut off the supply to a great extent, it became necessary to make these chains in this country. The separate links are first punched out on a small, specially designed press. The accompanying illustration shows the dimensions of one of these links, which at first were assembled by hand until finally an automatic machine was developed. After the chain has been assembled, it is put into what is known as a "suppling" machine. This machine detects and loosens tight rivet joints which may cause kinks in the chain and which would seriously affect the accuracy of the instrument. This is so serious a factor in the efficiency of the instrument that the Bureau of Standards has also built a special machine for this purpose. A graphic idea of the minuteness and cost of this chain may be gained from the statement that a double handful of the links contains about 250,000 pieces, valued at $4000. L. L. T.



Proportion of Links for Chains used on Altimeters

MICROMETER FOR SETTING CUTTER IN BORING-BAR

The large micrometer shown in the accompanying illustrations has been of value in setting the cutter in boring-bars when machining holes of large diameter. Fig. 1 shows the instrument being utilized in setting the cutter to bore a hole 9½ inches in diameter, the boring-bar, cutter, and the hole to be bored being indicated by dot-and-dash lines. The micrometer has two anvils which are held against the body of the boring-bar when a measurement is being taken to the cutting edge of the cutter. A special head was made for this micrometer, but a regular head could also be used. It is obvious that twice the distance *X* must be added to the diameter of the boring-bar in order to determine the diameter of the hole that will be bored by the cutter. A detail of the steel frame is shown in Fig. 2. NORMAN MCCLEOD

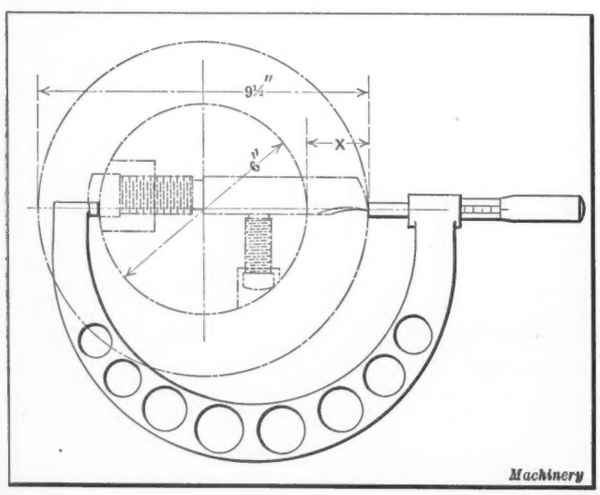


Fig. 1. Method of using Micrometer for setting Boring-bar Cutters

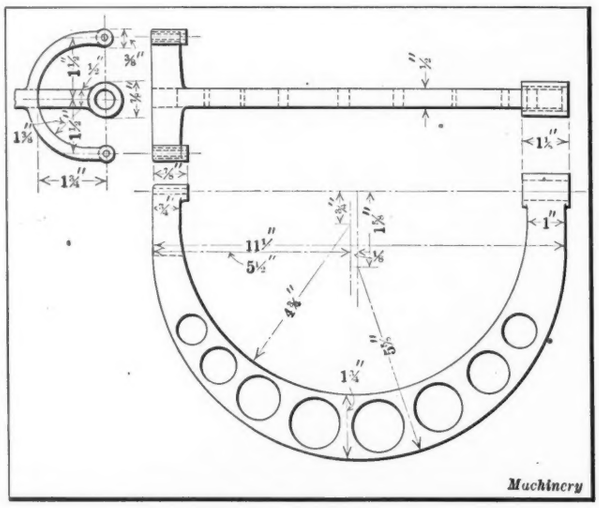
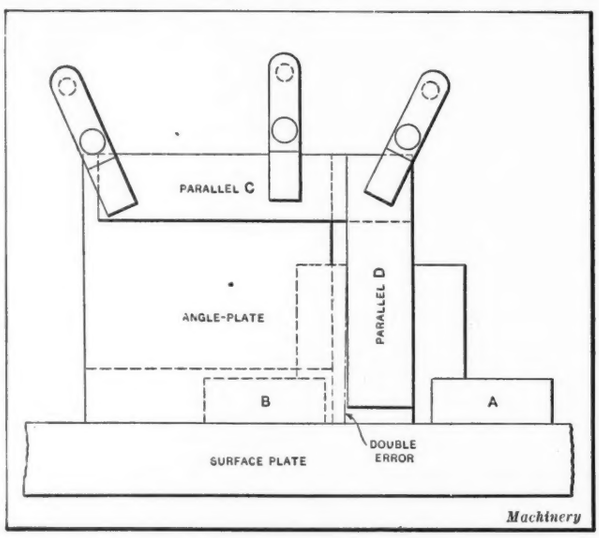


Fig. 2. Detail of Micrometer Frame

TESTING A SQUARE

The method described in this article for testing a square requires only the use of a surface plate, an angle-plate, a pair of parallels, and three small clamps, all of which are in common use in the average tool-room. The advantage of this method is that it shows a double error, thus allowing the error to be readily located and a more accurate adjustment to be made with less effort than by ordinary methods.



Set-up for testing a Square

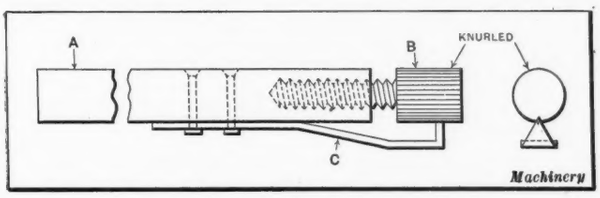
To test the square, an angle-plate is placed on a surface plate. A parallel is clamped to the angle-plate, as at *C* in the accompanying diagram. This parallel acts merely as an arm to which the parallel *D* is clamped perpendicular to the surface plate, and it need not therefore be accurately located. This parallel should overhang from the side of the angle-plate enough to admit light freely. The square to be tested is placed on the surface plate in position *A*, and the parallel *D* is adjusted until it shuts out light between the edge of the square and the side of the parallel. The square

is then moved to the opposite side of the parallel, as shown at *B*. It is evident that if any error exists, it will be indicated by the admission of light between the two adjacent edges, and that the space admitting the light will be twice as great as the actual error. Both the outside and inside edges of the square may be tested in this manner, the accuracy of the test being limited only by the accuracy of the tools used and the care taken in making the test.

Seattle, Wash. CARL E. SCHINMAN

ADJUSTABLE STOP FOR HAND SCREW MACHINES

The illustration shows an adjustable stop that has been advantageously used on a 2-inch Pratt & Whitney screw machine producing electric drill spindles, the lengths of which were held within a limit of 0.005 inch, plus or minus. When the regular stops were used, a large amount of time was spent in adjusting them because it was necessary first



Method of providing Adjusting Feature on Ordinary Stops

to loosen the set-screw on the stop-holder and then strike the stop lightly with a hammer or wrench in order to move it backward or forward until the correct position was obtained, after which the set-screw was again retightened. Often the point of the set-screw marred the surface of the bar, and when the screw was retightened, this would cause the bar to return to its original position.

All of this trouble was eliminated when the machine was equipped with the type of stop illustrated. A hole was drilled in one end of the regular bar stop *A* which was then tapped to a depth of about 1 inch with a ¼-inch tap having 32 threads per inch. The set-screw *B* was made from a piece of cold-drawn steel of the same diameter as the bar stop. A straight knurl was cut on the head of the screw, which was then casehardened. The spring *C* was made of ¼- by 1/32-inch spring steel, and was offset about 3/16 inch. The end of the spring which makes contact with the screw head, was machined to fit the knurls on the screw and thus hold it in place. The spring was secured to the stop by two 1/16-inch rivets. It was riveted in such a position that the contact point of the spring was central on the screw head when the screw was in the mean position, and as the head was ½ inch long, an adjustment of ¼ inch was obtainable in either direction. By the use of these stops, an operator can set up his machine fairly close in the usual manner and then make accurate settings by means of the adjusting feature.

Cicero, Ill. J. J. BORKENHAGEN

PRINTED FORMS FOR STANDARD GAGE DRAWINGS

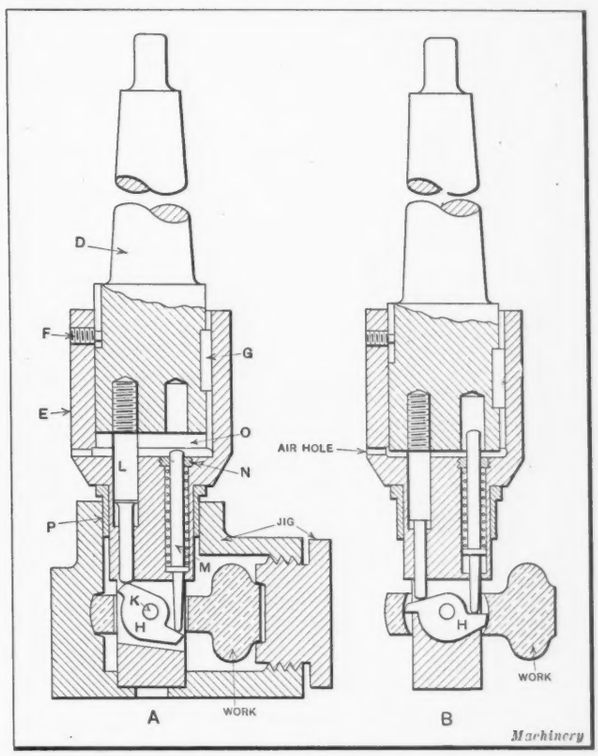
The following is a convenient method of making drawings of standard plug and snap gages. A printer's plate is made for each style gage, the variable gaging dimensions being left blank. Then as many copies as desired can be printed on tracing cloth or thin paper. The plate is made with heavy lines so that a good blueprint may be assured. With this method it becomes necessary only to fill in the "Go" and "Not Go" sizes and suitable title data on a copy in order to produce a working drawing of a gage, after which as many blueprints may be printed as desired.

The two following methods of making these drawings can also be used: (1) A master tracing is first made, from which "Van Dyke" prints are produced. The Van Dyke copy has blank spaces similar to those on the printed forms, and after these are filled in, blueprint copies are made for the tool-room, just as would be done with the original tracing-cloth drawing. This method, however, is expensive, and the resulting blueprints are frequently poor. (2) Copies from a master tracing are made by blueprinting. The blueprint copy serves as the original from which copies are made on the photostat machine. After the blank spaces are filled in on the photostat copies they are used for shop purposes. In view of the fact that the photostat method is also expensive, the printed drawing system seems to be preferable, and as it has given excellent results, it is almost sure to appeal to those chief draftsmen who handle large quantities of small gage drawings.

Syracuse, N. Y. ELMER C. COOLEY

TOOL FOR DRILLING A SPHERICAL HOLE

The accompanying illustration shows a device designed for drilling a 1-inch spherical hole in brass pieces, ½ inch thick, which were produced in large quantities. The taper shank of the body *D* is held in the spindle of a drill press. The socket end of the blade-holder *E* is fitted over the lower end of the body and is attached to it by means of the set-screw *F*, the point of which operates in a slot which allows for vertical movement of the body. Key *G* permits the body to drive the blade-holder. The swiveling blade *H*, is secured in the lower end of the blade-holder by stud *K*. Finger *L*, which bears against one end of the blade, is



Device used to drill Spherical Hole in Brass Pieces

screwed into body *D*, while finger *M* which bears against the other end of the blade, is held in a vertical hole in the blade-holder. This finger is forced downward by an expansion coil spring that it held between a shoulder on the lower end of the finger and the threaded bushing *N*.

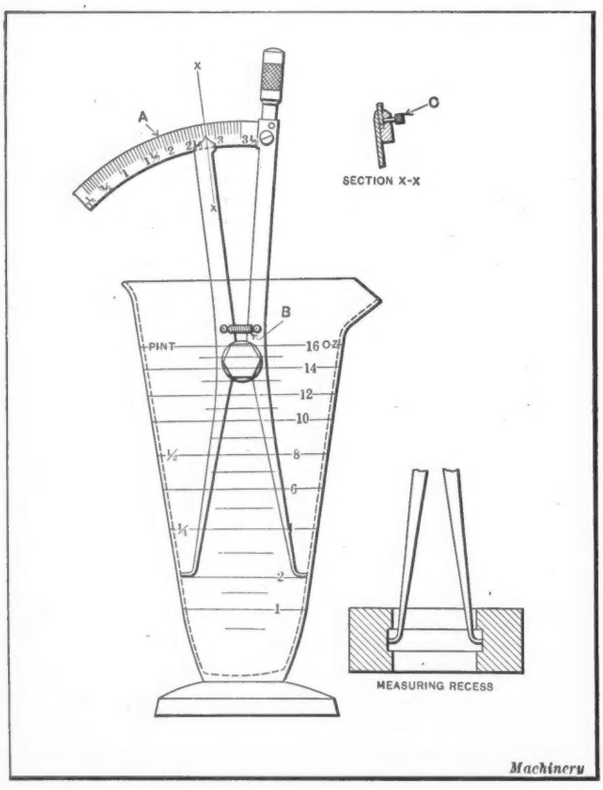
Before using this device, the work is placed in a jig and a straight hole is drilled through it, the diameter of which is about equal to the smallest diameter of the final spherical hole. After this operation has been completed the jig is located on the machine on which the spherical drilling operation is to be performed. The spindle of the machine is then lowered until the bottom end of the blade-holder *E* reaches the position in the jig that is illustrated at *A*. Up to this point the blade is held in the upright position illus-

trated at *A*, so that it can be inserted in the hole in the work. This is accomplished by the finger *M* pushing down on one end of the blade through the force exerted by the expansion spring. When this position has been reached, however, the blade-holder can no longer be lowered, and as the body *D* continues to descend by reason of the movement allowed by space *O*, the finger *L* acts upon the other end of the blade and overcomes the force exerted by the spring, thus causing the blade to swivel around stud *K*. In this manner, both ends of the blade are permitted to cut the sides of the hole as the blade revolves, until they reach the position shown at *B*, when the work is completed. As soon as the operator commences to raise the spindle of the machine, pressure is no longer exerted on the blade by finger *L*, and owing to the force exerted on the blade by the expansion spring through finger *M*, the blade is returned to the normal position as shown at *A*, before the blade-holder is withdrawn from the jig. Sleeve *P* is provided to guide the blade-holder into the opening in the jig. An average of two minutes was required for an unskilled workman to drill the straight and spherical holes in one piece, and only three blades were necessary to produce 10,000 pieces.

Ivry-Port, (Seine), France P. ROUQUET

INSIDE CALIPER OF SPECIAL DESIGN

The accompanying illustration shows an inside caliper which was originally designed for use in testing druggists' graduates, but which has also proved valuable as a tool for the machine shop. The proportions of the caliper are such as to provide a wide range of use, and the design is so simple as to require little skill to operate. By inserting the tool to the desired depth, the reading is taken directly on the attached bar *A*, one side of which may be graduated



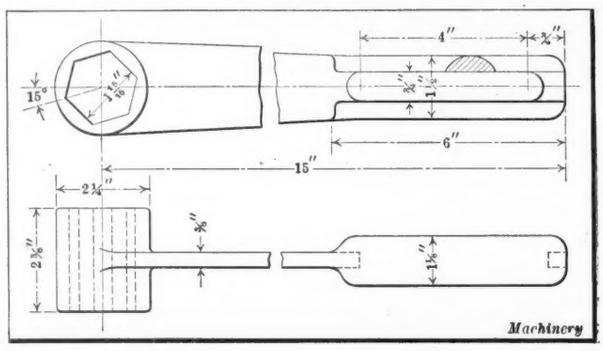
Inside Caliper with Graduated Arm and Indicator Arm

in units of English measurement and the opposite side in units of metric measurement. The compression coil spring *B*, as is apparent from the illustration, will keep the points spread when not in use, and will exert a certain amount of pressure on the internal walls of the work when taking the measurements. The screw *C* is provided to clamp the indicator hand in position so that duplicate measurements can be taken readily and quickly. In overhauling gas engines, this tool has been found very useful. The cylinders are usually worn in spots, and it becomes necessary to know the extent of this wear in order to determine whether reboring is required or not. For any boring or recessing job, in fact, this caliper will be found of especial value.

Beverly, Mass. V. G. TERRY

SOCKET WRENCH FOR LARGE COUPLING

The socket wrench shown in the accompanying illustration was made especially for use in connecting and disconnecting a large compression coupling used on heavy shafting. As the shafting was too heavy to be turned by hand, some difficulty was experienced in using an ordinary single-sided wrench having two sides of the hexagonal hole parallel with the handle. The special socket wrench shown, being



Double-sided Socket Wrench for tightening and removing Coupling Nuts in Inaccessible Positions

double-sided and having the hexagonal hole at 15 degrees, enabled the coupling nuts to be tightened or removed even when the coupling was in very inaccessible positions.

Watervliet, N. Y. MARTIN H. BALL

REDUCING INITIAL COST OF STRADDLE-MILLING CUTTERS

Two side milling cutters were required for a certain straddle-milling operation which it was desired to carry on almost continuously. The cutters were of large size and cost nearly two hundred dollars each; the purchase of two extra cutters so that one set could be ground while the other was in use was an expense out of proportion to the returns for the work, yet the time lost in sharpening after both sides of each cutter became dull was an item too large to be overlooked.

The scheme adopted was to buy one extra cutter. The two cutters on the machine could then be kept in operation while the third was being ground. When the opposing edges of the running pair became dull, instead of reversing these two as is customary, one cutter was removed and the other reversed and set up with the sharp cutter. Following this practice, there was never any delay in changing cutters more than that which occurs in changing to another set of cutters or at a change of position. The more frequent grindings were not a source of extra work as the operation was performed on a cutter grinder regularly employed on this class of work. By this simple method, which could be applied to similar work, the required number of cutters is reduced and a saving in cost effected.

Middletown, N. Y. DONALD A. HAMPSON

* * *

The most important developments in Australian industry during the war were in connection with engineering and associated trades. Factories were started for building a great many classes of machines and supplies not previously made in that country, including high-speed steam engines, piston-rods, airplane engines, gas engines, Diesel engines for marine work, hydraulic machinery, machine tools, etc.

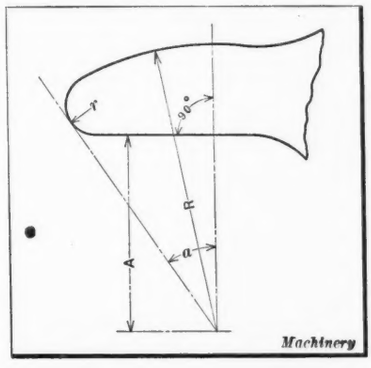
HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

UNITED STATES STANDARD OF LENGTH

J. C. N.—Is it true that the meter is the legal standard of length in the United States?

A.—While the yard is the commonly accepted standard, the meter is the legal standard of length. The original standard is kept at the International Bureau of Weights and Measures in France. This standard is a platinum-iridium bar having three exceedingly fine lines at each end. When the temperature of this bar is 0 degrees C. (32 degrees F.), the distance between the middle lines of each end is equivalent to one meter by definition. The United States Bureau of Standards has two copies of this original or primary standard. The legal equivalent of the meter for commercial purposes is 39.37 inches, this value being exact within the error of observation. These standard bars at Washington are the ultimate standards of reference for manufacturers of precision measuring instruments, etc., and working standards or duplicates have been made for their use.



MATHEMATICAL PROBLEM

W. G. W.—The accompanying illustration shows a problem encountered in designing a field pole tip which is submitted to the readers of MACHINERY for solution. The only known dimensions are the radius R, distance A, and the size of angle a. It is required to find radius r of the arc as shown.

HEAT-TREATMENT FOR GEARS

P. H. B.—The following heat-treatment was given to clashing tractor transmission gears cut from bar stock containing 0.15 to 0.25 per cent carbon, 0.35 to 0.65 per cent manganese, 0.30 to 0.65 per cent chromium, 1 to 1.5 per cent nickel, and not over 0.04 per cent sulphur and 0.04 per cent phosphorus:

1. Carburized nine hours in E. F. Houghton & Co.'s "quick light A" at 1500 degrees F.
2. Allowed to cool slowly in carburizer.
3. Reheated to 1200 to 1250 degrees F.
4. Quenched in water at about 50 to 60 degrees F.

The above treatment was according to advice given by the steel manufacturers. However, the gears were too hard for practical use, giving a hardness test of 100 to 125 on the scleroscope.

Another treatment was given the gears as follows:

5. Annealed by heating to about 1350 degrees F.
6. Reheated to 1350 degrees F.
7. Quenched in oil at room temperature.

The gears were still too hard, an analysis showing 0.61 per cent carbon, with a case existing apparently throughout. However, it is desired to have a hard wearing surface with a tough core for strength. Can these gears be made usable by any further treatment? Would it be possible to draw out the carbon without introducing other impurities, by reheating them in the presence of slag, silicon, sand, or some other non-carburizing substance?

If the steel were 0.40 per cent carbon, instead of 0.20 per cent to begin with, would the carburizing treatment given above produce only an average of 0.61 per cent carbon? Assuming they were from 0.40 per cent carbon alloy steel, with all other percentages the same as given, what further treatment would make them fit for use as clashing tractor transmission gears? The gear is small and was machined to the following dimensions: 4 inches pitch diameter; 8 diametral pitch; 2 inches face; 1¼ inches bore. The hub is 2½ inches diameter and 4 inches long.

TRIGONOMETRIC PROBLEM

F. E. M.—The diagram shows a disk which is laid against the two surfaces AE and AF, located at right angles to each other. If a size block of known dimensions is placed as shown, how can the diameter of the disk be calculated which will be tangent to both sides and to the corner of the size block?

ANSWERED BY GUY H. GARDNER, NEW LONDON, N. H.

Assume the dimensions of the size block to be ¼ by ½ inch, the length being arbitrary; then the diameter of the disk may be found in the following manner.

By geometry, if from a point without a circle, a secant and a tangent are drawn, as AC and AD, the tangent is the mean proportional between the whole secant and its exterior section. Hence

$$AC = \frac{AD^2}{AB}$$

But $AD = R$ = radius, and by trigonometry $AC = \frac{R \sin COA}{\sin OAC}$; therefore:

$$\frac{R^2}{AB} = \frac{R \sin COA}{\sin OAC}$$

Simplifying,

$$R = \frac{AB \sin COA}{\sin OAC}$$

Angle $OAD = 45$ degrees; tan angle $DAB = \frac{0.25}{0.50}$; $DAB = 26$ degrees 33 minutes 55 seconds; angle $OAC = 45$ degrees — 26 degrees 33 minutes 55 seconds = 18 degrees 26 minutes 5 seconds.

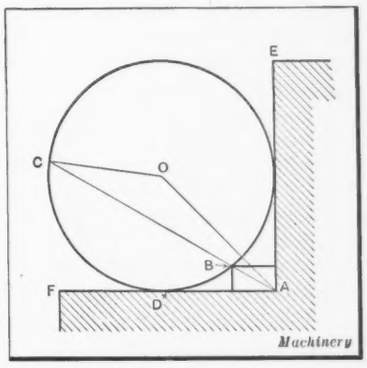


Diagram used in Connection with solving a Trigonometric Problem

$OA = 1.414R$; then by the law of sines,

$$\frac{1.414R}{R} = \frac{\sin OCA}{\sin OAC}$$

$\text{Sin } OCA = 1.414 \sin OAC = 1.414 \times 0.31622 = 0.44714$

$OCA = 26$ degrees 33 minutes 37 seconds

$COA = 180$ deg. — $(OAC + OCA) = 180$ deg. — (18 deg. 26 min. 5 sec. + 26 deg. 33 min. 37 sec.) = 135 deg. 18 sec.

$AB = \sqrt{\frac{1}{4} + \frac{1}{2}} = 0.559$ inch

Therefore

$$R = \frac{0.559 \times 0.70705}{0.31622} = 1.250 \text{ inch}$$

and the diameter of the disk equals 2×1.25, or 2.50 inches.

TO DRAW A CIRCLE TANGENT TO THREE GIVEN CIRCLES

M. A. C.—Is there any exact geometrical construction for drawing a circle tangent to three circles that are tangent to each other? For example, if the diameters of three circles are 2, $1\frac{7}{8}$, and $1\frac{1}{16}$ inches, what is the smallest circle that will include them?

ANSWERED BY C. N. PICKWORTH, MANCHESTER, ENGLAND

An answer to this problem was given in the March, 1917, number of MACHINERY in which the center of a circumscribed circle was found by modern or projective geometry. This method is very complicated: it requires a large number of operations, but gives no means of calculating the diameter

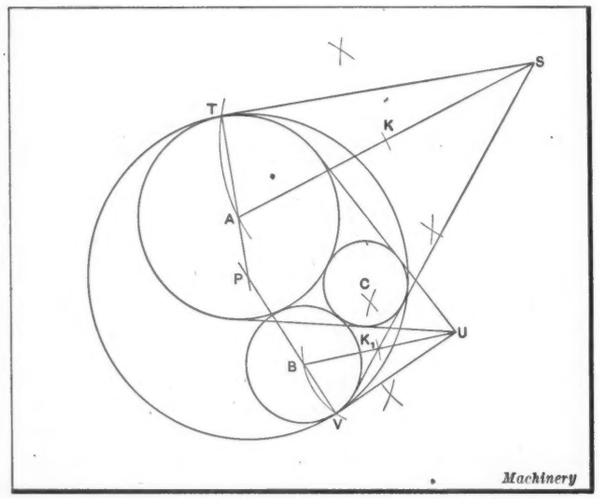


Fig. 1. Diagram illustrating Method of drawing a Circumscribed Circle Tangent to Three Given Circles

of the circumscribed circle. The following solution is based upon the following geometric theorem: If three circles are mutually tangential, a line drawn from the center of similitude of two of the circles tangent to the third circle, is also tangent to a circle which is tangent to the three circles.

The meaning of this somewhat involved statement will be more readily understood by referring to the diagram Fig. 1, in which the center of the circumscribed circle is found in the following manner: Draw two lines tangent to circles B and C which intersect at S, their center of similitude. Draw TS tangent to circle A, and at the point of tangency erect a perpendicular, which will pass through the center of circle A. Next draw two lines tangent to circles A and C, which will intersect at U, their center of similitude, and draw line VU tangent to circle B. From this point of tangency also erect a perpendicular, which will pass through the center of circle B. The point of intersection of this perpendicular and the line perpendicular to TS will be the center, P, of the circumscribed circle. The radius of this circle can be solved by the following formula:

$$R = \frac{abc}{2\sqrt{abc\,(a+b+c)} - (ab+bc+ac)}$$

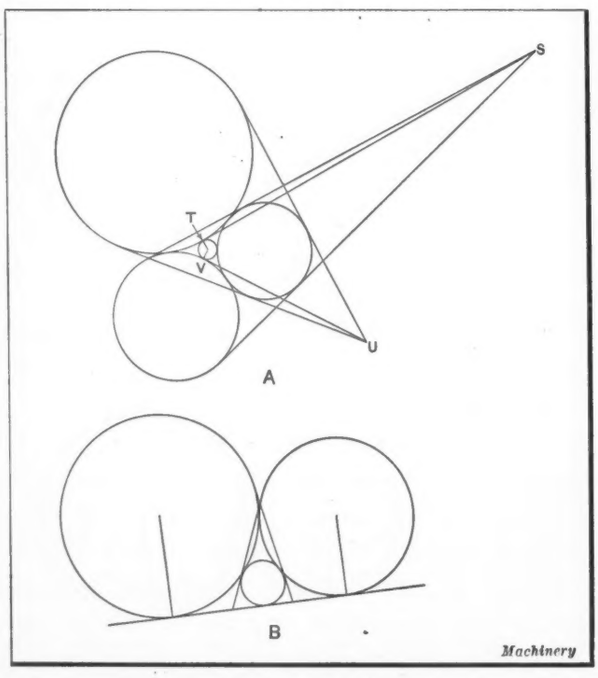


Fig. 2. (A) Method of drawing Inscribed Circle Tangent to Three Circles. (B) Diagram illustrating Case in which a Common Tangent to Three Circles is a Straight Line

in which

R = radius of circumscribed circle;
a = radius of circle A;
b = radius of circle B;
c = radius of circle C.

If A is 2 inches in diameter; B, $1\frac{7}{16}$ inches; and C, $1\frac{1}{16}$ inches; then $a = 1$ inch; $b = 23/32$ or 0.71875 inch; and $c = 17/32$ or 0.53125 inch. Substituting these values in the above formula the following is obtained:

$$R = \frac{0.38184}{1.85378 - 1.63184} = 1.720 \text{ inches}$$

Therefore the diameter of the circumscribed circle is $2 \times 1.720 = 3.440$ inches.

As accuracy is required in laying out this diagram, in order to locate the center of the circumscribed circle exactly, perpendicular TP should be erected in the following manner, which eliminates the necessity of drawing TS and reduces the chance of errors. Draw AS from the center of similitude to the center of the circle and bisect this line at K as shown. Then with KA as a radius, draw an arc intersecting the circumference of the circle at T, after which line TP can be drawn by intersecting point T and center A. The same method should also be used in drawing perpendicular VP.

If the tangent lines TS and VU had been drawn to the opposite points of tangency, as shown at A in Fig. 2, the intersection of the two perpendiculars erected from this point of tangency would have been the center of an inscribed circle tangent to the three circles. In cases where the line tangent to three circles is a straight line, the perpendicular lines erected by the first method will not intersect but will be parallel as shown at B, Fig. 2. When one of the circles is so small that it is within a line tangent to the other two circles, as shown in Fig. 3, the perpendiculars erected by the first method described give the center of a circle which is tangent to the three circles but which does not circumscribe the circles. The formula for finding the radius of such a tangential circle is as follows:

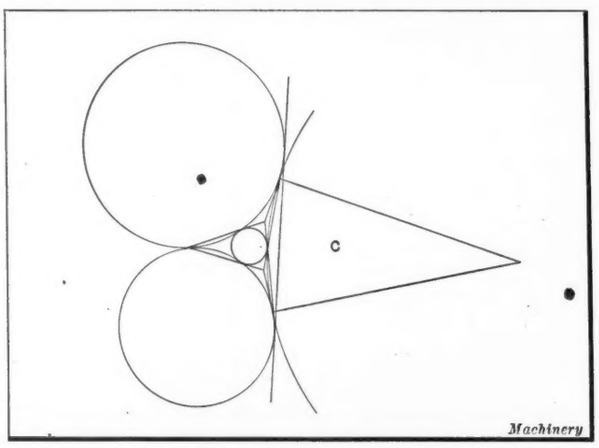


Fig. 3. Case in which the Smallest of Three Tangent Circles is within a Line Tangent to the Other Two Circles

$$R = \frac{abc}{ab+bc+ac-2\sqrt{abc\,(a+b+c)}}$$

in which the various letters represent the same elements as in the previous formula. The writer is indebted to C. V. Durell for the evolution of these formulas.

* * *

In order to improve the facilities of the United States in obtaining reliable information relating to foreign trade, the National Civil Service Reform League has issued a statement relating to foreign service requirements, with suggestions for improvements in the personnel and organization of the consular and other foreign service, with the view, particularly, of taking this important branch of our government out of the political patronage domain.

STANDARD TIME IN CONNECTION WITH TIME-STUDY WORK

By J. B. CONWAY

In adopting time-study methods, the first question that arises concerns establishing a basis from which to determine the standard time allowance after the actual or average time has been obtained. There are several methods for obtaining this standard. On account of the misunderstandings which obtain regarding methods of computing standard time, the accompanying chart has been prepared by the writer, to assist in clarifying the subject. It must not be inferred, however, that this is in any sense a "short cut" in the actual making of a time study. It is only for the purpose of comparison and of simplifying the work of establishing the standard time.

Use of a Constant in Establishing Standard Time

There are several methods in use for computing standard time after the time study has been made. The one which is perhaps the most widely used consists of dividing the average time taken from the study by a constant. This constant varies with the nature of the work and is governed by variable factors which enter into the performance of the task. The result obtained is the standard time, or, expressing this as a formula:

$$\text{Standard time} = \frac{\text{Average time}}{\text{Constant}}$$

Assume, for example, that we have an average time of 3.2 minutes, and that the constant to be used is 0.70; then according to the formula, the standard time would be 4.57 or approximately 4.6 minutes. Referring to the chart, the same result may be obtained with much less effort. Entering the chart at the left on a line representing the average time of 3.2 minutes, and following it across to the point where the line intersects the line of the constant 0.70, then upward to the standard time line, we find the standard time to be 4.6 minutes. This procedure is reversed where the standard time is given in order to obtain the average or base time. This method, if a constant of 0.70 is used, increases the standard time a trifle more than would be obtained by adding 30 per cent to the average time.

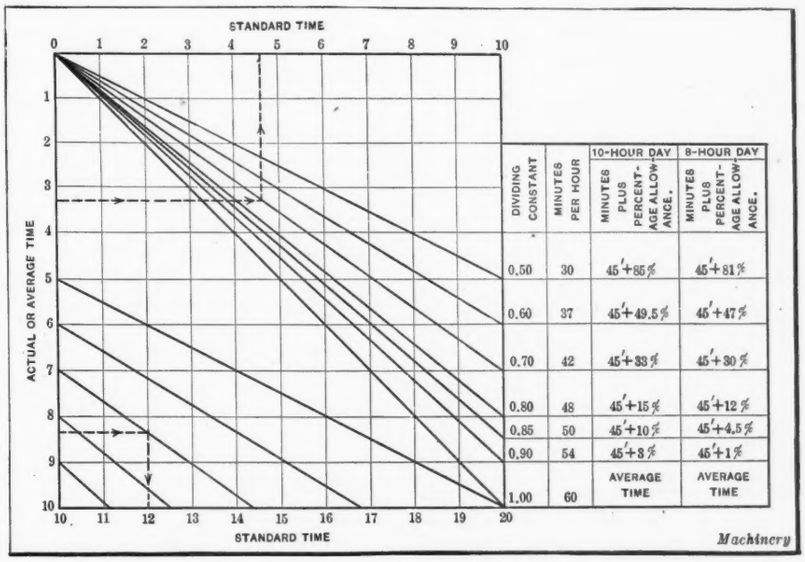

STANDARD TIME
0 1 2 3 4 5 6 7 8 9 10
ACTUAL OR AVERAGE TIME
1 2 3 4 5 6 7 8 9 10
10 11 12 13 14 15 16 17 18 19 20
STANDARD TIME
DIVIDING CONSTANT
MINUTES PER HOUR
10-HOUR DAY
MINUTES PLUS PERCENTAGE ALLOWANCE.
8-HOUR DAY
MINUTES PLUS PERCENTAGE ALLOWANCE.
0.50 30 45′+85% 45′+81%
0.60 37 45′+49.5% 45′+47%
0.70 42 45′+33% 45′+30%
0.80 48 45′+15% 45′+12%
0.85 50 45′+10% 45′+4.5%
0.90 54 45′+3% 45′+1%
1.00 60 AVERAGE TIME AVERAGE TIME
Machinery

Chart for determining Standard Time in Time Studies

The diagonal lines in the lower left-hand corner of the chart merely extend the range. It will be observed that the same horizontal lines on which the diagonal lines end at the right, are the lines from which the diagonal lines commence again from 5 to 10 at the left of the chart. It is not necessary to mark these diagonals on the bottom line, as the index numbers at the left can be made to serve as indices for the diagonals as well. As an example of the use of these diagonals, assume the average time to be 8.40 minutes. Entering the chart on the left, on the 8.40 minute line and traveling across until this line intersects the diagonal representing the allowance to be made, in this case 0.70, then downward to the bottom of the chart, the standard time is found to be 12 minutes.

Method which Uses Percentages for Various Factors

Another method for establishing the standard time is to analyze the various operations, conditions, and other elements entering into the work, and allow a definite percentage for such factors as fatigue, personal care, and machine and tool troubles, with another percentage added as an incentive to the operator. The formula for this method is somewhat involved and is as follows: First, from the total working minutes in a day, subtract the machine, tool, and miscellaneous allowance, to obtain the net working minutes. Second, divide the number of net working minutes by the net average time per piece, obtaining the number of units completed per day. Third, divide the total working minutes by the number of units per day, giving the time allowance per piece. Fourth, multiply the time allowance by 1 plus the percentage allowed as an incentive to the operator; the result is the standard time. The standard time, then, is the sum of all allowances added to the average time required to machine one piece.

Thus, for a ten-hour day, again using 3.2 minutes as the average time per piece and the above formula,

$10 \times 60 - 45$ (machine, tool and miscellaneous allowance) $= 555$ minutes (1)

$\frac{555}{3.20} = 173$ pieces per day (2) $\frac{600}{173} = 3.46$ min. per piece (3)

$3.46 \times (1 + 0.33) = 4.6$ minutes, standard time (4)

To obtain the same result from the chart, it will be noted that the line representing the constant 0.70 is marked 45 minutes + 33 per cent, under the heading "Minutes plus Percentage Allowance, 10-hour Day." This constant is, therefore, the one to employ, and following it through in the same manner as in the first example, we get the same standard time, or 4.6 minutes.

Another method is one in which the base is established as a certain number of minutes per hour, making an allowance which is supposed to include all necessary time such as cited in the second method. This allowance also varies, but not to the extent that the other allowances vary, and is therefore not as flexible. However, it may be made so, as is shown by the chart. To the right, in the column marked "Minutes per Hour" is given a time which is the equivalent of that obtained by dividing the actual number of minutes per hour by the constant. Thus, again using the same average time as before, 3.2 minutes, and the same time allowance, we find the standard time, 4.6 minutes per piece, and then applying the formula

$$\frac{\text{Average time} \times 60}{\text{Net working time}} = \text{Minute-hour}$$

This gives $\frac{3.2 \times 60}{4.6}$ or 42-minute-hour, which if divided by 3.2 equals 13.1 pieces per hour, and this divided into 60 minutes gives the standard time, 4.58 minutes, which if expressed to the nearest tenths is 4.6 minutes; or the same result may be obtained by dropping the decimal and calling 13 pieces correct for an hour's work. Either of these results

is close enough for general work. For an 8-hour day, using the same allowance in minutes, the percentage changes slightly. If fractional percentages occur it may be found advisable to decrease or increase the percentage to the next whole figure.

Recognized Factors Entering into the Subject of Time Study and Forming the Basis upon which the Chart is Constructed

The chart is indexed with whole numbers from 0 to 10; but, of course, these values may be multiplied or divided by 10 or any multiple thereof; for example 3.2 may be assigned values thus; 0.032, 0.320, 3.2, 32.0, 320, etc., the results obtained depending, of course, upon the value given these index numbers at the left margin. A little practice will enable anyone to use the chart intelligently and with slight chance of error. The original for the chart here shown was 5 inches square, and therefore fractional times are more or less difficult to read. The larger the chart can be made, to be used with convenience, the greater accuracy will be obtained. If a chart is made 20 inches square, it will be found to be about the right size.

It will perhaps be helpful to present here some of the factors and percentage allowances used by Frederick W. Taylor in his well-known time-study work.

1. Light work, calling for no special fatigue, such as ordinary shop practice, 30 per cent.

2. Ordinary labor, calling for severe bodily exertion and strength with resultant fatigue, 50 to 80 per cent.

3. Special skill or brain power, with close application but requiring no bodily exertion, 70 to 80 per cent.

4. Skill, brain energy, close application, and extreme bodily exertion, such as running a steam hammer, 80 to 100 per cent.

Other industrial engineers agree approximately on these figures, and Mr. Taylor has pertinently remarked that these factors are not to be theorized over, but are facts obtained by costly experiments.

The manner in which these percentages may be employed has been shown to some extent in this article, and other combinations may be obtained if one cares to go deeply enough into the subject, but those chosen will meet ordinary requirements. Attention is called to the method of establishing a definite "minute-hour" such as is shown in the chart. If a definite time is made to suit all classes of work in the shop, it will be found to work to disadvantage. Let us assume a case where the work in the machine shop is of such a type that an allowance of, say, 30 per cent is found suitable, whereas the work in the foundry of the same concern is of a considerably different type, and the element of fatigue is of more importance. If an allowance of 30 per cent for the machine shop should be made, it would probably develop that a greater amount than this should be allowed those operators in the foundry who do heavier work. Possibly from 50 to 80 per cent would be found justifiable in the latter case. Therefore, in adopting this method, by the use of the chart one may obtain the desired percentage as well as the minute basis per hour, and yet maintain the original dividing constant basis. A careful study of the foregoing will enable one to select the method best suited to his particular requirements.

* * *

At the convention of the Iron and Steel Electrical Engineers in St. Louis, Mo., a report presented by the electric-furnace committee of the association outlined the present status of electrical furnaces in the steel industry. The discussion brought out the insufficiency of the available technical literature on electric-furnace reactions. Concerning furnace-lining thicknesses, the opinion was expressed that too thin a lining wasted heat, while an abnormally thick lining limited the capacity of the furnace. The careful training of the operator was considered to be of paramount necessity for securing the successful operation of any electric furnace. It was stated that the furnace body should be of such shape as to give equal heat at every point.

DEVICE FOR RAISING PLANER TOOL DURING RETURN STROKE

By D. R. GALLAGHER

The device shown in Fig. 1 has been used successfully to prevent the cutting edge of a planer tool from dragging on the work during the return traverse of the table. It is well known that the cutting edge of a planer tool is often worn off by dragging on the work during the return traverse quite

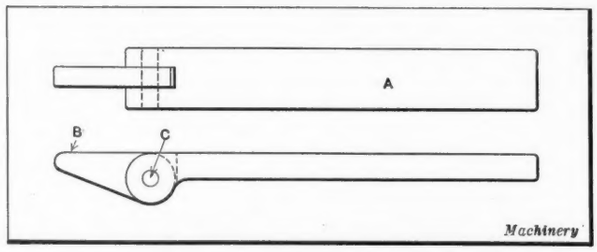


Fig. 1. Device which prevents Planer Tool from dragging on Work during Return Traverse of Planer Table

as rapidly as it is while taking a cut. For this reason, the device shown is particularly useful when planing long pieces of work in which wear on the cutting edge, from this source, is most objectionable. As shown in Fig. 1, the device consists simply of a shank *A*, made from mild steel about the width of the planing tool, and the tongue *B* which swings easily on pin *C*.

At *D*, Fig. 2, is shown the device in the position which it occupies during the forward or cutting traverse. It will be seen that the shank is clamped between the planer tool and the clapper-box with tongue *B* dragging on the work. At *E* the device is shown in operation as it appears on the return traverse of the table. It will be seen that the tongue, when it comes in contact with the work, serves to rock the clapper-box forward, thus raising the tool from the work. The tool is supported in this position during the return of the table, but again comes in contact with the work when the motion of the table is reversed, and the tongue is swung in the opposite direction so as to drag on the surface of the work again, as shown at *D*. A similar result may be obtained by placing a spring under the clapper-box and thus raising the tool from the work during the return of the table; but, if this arrangement is employed, the depth of cut should be greater than the distance through which the

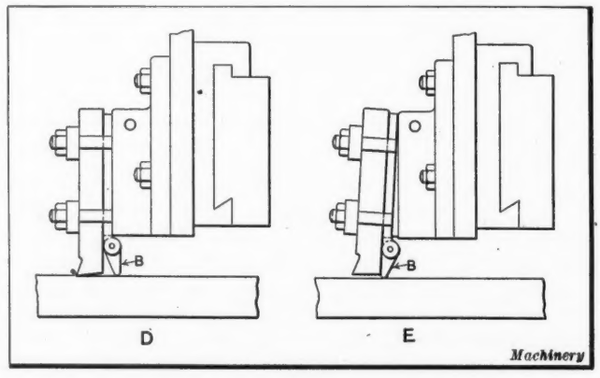


Fig. 2. Illustration which shows Operation of Protecting Device during Forward and Return Traverses of Planer Table at D and E, respectively

spring raises the tool, otherwise the tool would not come into proper contact with the work on the forward traverse. The device shown in Fig. 1, however, will function satisfactorily when the cut is only a few thousandths inch deep.

* * *

The Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., has recently developed an electric automobile engine heater, to keep the engine warm while standing in the garage and to insure easy starting. It is said to have a power consumption of only 100 watts.

Combined Stresses

By VICTOR M. SUMMA, Engineering Examiner, American Brake Co., St. Louis, Mo.

ST. Venant's formulas for the analysis of shear and tension or compression stresses in machine parts (when these stresses are acting simultaneously and normally to each other) can be conveniently expressed in the following forms:

$$P_1 = \frac{S}{2} + \sqrt{\left(\frac{S}{2}\right)^2 + S_s^2} \qquad (1)$$

$$P_2 = \sqrt{\left(\frac{S}{2}\right)^2 + S_s^2} \qquad (2)$$

in which S is the tensile or compressive unit stress, S_s the shear unit stress, and P_1 and P_2 their maximum resultants in tension, or compression, and in shear, respectively, remembering that P_1 is tension if S is tension, and compression if S is compression.

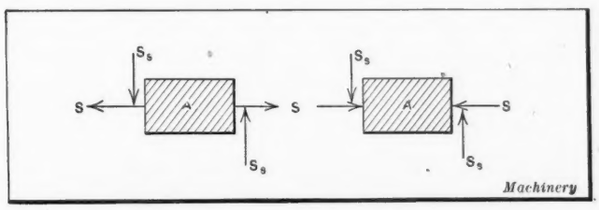
These original and fundamental equations (1) and (2) admit of many transformations, some of which are very useful. Unfortunately, however, the derived formulas are sometimes misapplied and it is not uncommon to hear engineers speak of them as antiquated and incorrect.

It is the purpose of this article to explain the use of two of the most familiar derivations of St. Venant's formulas, namely:

$$M_e = \tfrac{1}{2}M + \tfrac{1}{2}\sqrt{M^2 + T^2} \qquad (3)$$

$$T_e = M + \sqrt{M^2 + T^2} \qquad (4)$$

where M and T represent the bending and twisting moments to which a round shaft is simultaneously subjected, and M_e and T_e their equivalent moments, that is, the so-called "equivalent" bending moment and the "equivalent" torsional moment, respectively.



Diagrams showing how Tension and Compression Forces S and Shear Stresses Ss act simultaneously on an infinitely Small Portion of a Body subjected to these Combined Stresses. The Diagram at the Left shows S in Tension and the One at the Right shows S in Compression

If an infinitely small portion A of a strained body is under stresses as shown in the accompanying diagrams, that is, if the tension or compression stress S and the shear stress S_s are acting at the same instant and normally to each other on a certain material point A, then there exists a definite plane in which their combined effect in tension, or compression, is a maximum, expressed by formula

$$P_1 = \frac{S}{2} + \sqrt{\left(\frac{S}{2}\right)^2 + S_s^2}$$

and another plane as definitely fixed as the first, in which their maximum combined effect in shear is

$$P_2 = \sqrt{\left(\frac{S}{2}\right)^2 + S_s^2}$$

Should it be necessary we could even determine the position of these planes, though the intensity rather than the direction of the stresses P_1 and P_2 is ordinarily required.

Hence, if a shaft 5 inches square in cross-section is subjected to a twisting moment $T = 200{,}000$ inch-pounds and at the same time to a bending moment $M = 260{,}000$ inch-pounds, the problem of ascertaining the greatest stresses in the material is wholly within the scope of the Formulas (1) and (2). In fact, if Z and Z_p represent the rectangular and polar moduli of section respectively, then

$$Z = \frac{5^3}{6} \text{ and } Z_p = \frac{2}{9} \times 5^3;$$

and since

$$S = \frac{M}{Z} \text{ and } S_s = \frac{T}{Z_p}$$

we have, by substitution,

$$S = \frac{260{,}000 \times 6}{5^3} = 12{,}500 \text{ pounds}$$

$$S_s = \frac{9 \times 200{,}000}{2 \times 5^3} = 7200 \text{ pounds}$$

$P_1 = 6250 + \sqrt{6250^2 + 7200^2} = 15{,}800$ pounds per square inch in tension or compression

$P_2 = \sqrt{6250^2 + 7200^2} = 9550$ pounds per square inch in shear.

In a similar way, if the shaft were round instead of square and its diameter was, say, 5 inches, we would have:

$$Z = \frac{5^3}{10.2} \text{ and } Z_p = \frac{5^3}{5.1}$$

$$S = \frac{260{,}000 \times 10.2}{5^3} = 21{,}220 \text{ pounds}$$

$$S_s = \frac{200{,}000 \times 5.1}{5^3} = 8150 \text{ pounds}$$

$P_1 = 10{,}610 + \sqrt{10{,}610^2 + 8150^2} = 24{,}000$ pounds per square inch in tension or compression.

$P_2 = \sqrt{10{,}610^2 + 8150^2} = 13{,}400$ pounds per square inch in shear (B). Thus it is seen how St. Venant's original and fundamental equations apply equally well to square and round shafts; indeed, they can be applied to any bars of which the rectangular and the polar moduli of section are known.

We will now see how Equation (1) may be transformed into (3) and (4), namely the formulas for the specific and limited case of round bars, and why these derivations should be used in connection with nothing but round bars.

Remembering that for round cross-sections the modulus of section for torsion is twice that for flexure, that is, that Z_p is equal to $2Z$, we have as unit stresses

$$S = \frac{M}{Z} \text{ and } S_s = \frac{T}{2Z}$$

Substituting above values in formula for P_1

$$P_1 = \frac{M}{2Z} + \sqrt{\frac{M^2}{4Z^2} + \frac{T^2}{4Z^2}} = \frac{1}{2Z}\left(M + \sqrt{M^2 + T^2}\right)$$

$$P_1 = \frac{M + \sqrt{M^2 + T^2}}{2Z} = \frac{\tfrac{1}{2}M + \tfrac{1}{2}\sqrt{M^2 + T^2}}{Z} \qquad (a)$$

Calling the numerator of the first fraction by the symbol T_e and the numerator of the second by M_e, we have, since $2Z = Z_p$,

$$P_1 Z_p = T_e \text{ and } P_1 Z = M_e$$

In other words, since stress P_1 is multiplied by Z_p—the polar modulus of section for twisting—the symbol T_e is simply an imaginary twisting moment equivalent to $M + \sqrt{M^2 + T^2}$; since P_1 is multiplied by Z—the plain modulus of section

for bending—the symbol M_e is an imaginary bending moment equivalent to $\frac{1}{2}M + \frac{1}{2}\sqrt{M^2 + T^2}$. Hence the well-known expressions:

$$M_e = \tfrac{1}{2}M + \tfrac{1}{2}\sqrt{M^2 + T^2} \qquad (3)$$

$$T_e = M + \sqrt{M^2 + T^2} \qquad (4)$$

But, whether M_e or T_e, these symbols refer only and always to P_1 the tensile (or compressive) stress, and not at all to P_2, namely, the shear, as is generally thought when the formula for the equivalent twisting moment is used. Indeed, we can, in a measure, appreciate the necessity of discriminating between the two sets of formulas by comparing the change in result when any of the derivations (3) and (4) is used to solve the previous problem of the 5-inch square shaft, as we would then have

$$P_1 = \frac{T_e}{Z_p} = \frac{260{,}000 + \sqrt{260{,}000^2 + 200{,}000^2}}{2 \div 9 \times 5^3} = 21{,}160 \text{ pounds}$$

which of course is too great a value, the more exact answer being 15,800 pounds as determined by the first solution.

Now that the equivalent bending moment and the equivalent twisting moment have been considered, we can go one step farther (in fact, since Formulas (3) and (4) give only tension or compression stresses, it is necessary to take another step if the *shearing* stresses are to be determined), and transform the general equation (2) at the beginning of the article into new formulas for the specific and limited case of round bars.

This is readily done, since the only difference in form between the expressions of the values of P_1 and P_2 is the term outside the radical in Equation (1), and the transformation of the radical is naturally the same in both cases. So, the fractions in Formula (a) of P_1 are readily changed to

$$P_2 = \frac{\sqrt{M^2 + T^2}}{2Z} = \frac{\frac{1}{2}\sqrt{M^2 + T^2}}{Z} \qquad (b)$$

Or, using the symbols M_{es} and T_{es} to indicate $\frac{1}{2}\sqrt{M^2+T^2}$ and $\sqrt{M^2+T^2}$ respectively, we have (remembering that $2Z=Z_p$):

$$T_{es} = P_2 Z_p, \qquad M_{es} = P_2 Z$$

which show that T_{es} is simply another imaginary twisting moment, and that M_{es} is another imaginary bending moment; but, since we are dealing with P_2, they will give shearing stresses only.

Hence we can write down the following important results:

$$M_{es} = \tfrac{1}{2}\sqrt{M^2 + T^2} \qquad (5)$$

$$T_{es} = \sqrt{M^2 + T^2} \qquad (6)$$

These new derivations of St. Venant's, then, are as definite and distinct as the old Formulas (3) and (4), and like them are only good for round shafts, or any bars, the cross-sections of which are circular in shape.

Formula (6) is known as Guest's formula, but Guest used it to find the tensile stresses only, thus making an empirical formula out of an otherwise thoroughly theoretical derivation.

In order to check the correctness of the above formulas, we might use them to find the maximum stress P_2 in the preceding example of the 5-inch round shaft, and see whether it gives the same value as Formula (B), namely, 13,400 pounds derived by the use of Formula (2).

Referring to Formula (5) it will be seen that

$$P_2 = \frac{M_{es}}{Z} = \frac{1}{2} \times \frac{\sqrt{260{,}000^2 + 200{,}000^2}}{5^3 \div 10.2} = 13{,}400 \text{ pounds}$$

or, by (6)

$$P_2 = \frac{T_{es}}{Z_p} = \frac{\sqrt{260{,}000^2 + 200{,}000^2}}{5^3 + 5.1} = 13{,}400 \text{ pounds}$$

In summing up it may be convenient to group the two sets of formulas on round members under combined bending and twisting moments as follows:

Equivalent bending moment for *tension and compression* equals

$$\tfrac{1}{2}M + \tfrac{1}{2}\sqrt{M^2 + T^2} = M_e = P_1 Z$$

Equivalent twisting moment for *tension and compression* equals

$$M + \sqrt{M^2 + T^2} = T_e = P_1 Z_p$$

Equivalent bending moment for *shear* equals

$$\tfrac{1}{2}\sqrt{M^2 + T^2} = M_{es} = P_2 Z$$

Equivalent twisting moment for *shear* equals

$$\sqrt{M^2 + T^2} = T_{es} = P_2 Z_p$$

It must be apparent from these considerations, that there is nothing wrong with Formulas (3) and (4), and, that with the understanding that they must be limited in their application to circular cross-sections, they are as correct as St. Venant's original Formula (1) from which they are derived.

The introduction of the factor of lateral contraction (the so-called Poisson's ratio) into St. Venant's equations should not go unnoticed by those whose work demands exceptional care and exactness, as is necessary, for instance, in the manufacture of guns. Formulas (1) and (2) could, in the case of steel, be written

$$P_1 = (1 - R)\frac{S}{2} + (1 + R)\sqrt{\left(\frac{S}{2}\right)^2 + S_s^2}$$

$$P_2 = (1 + R)\sqrt{\left(\frac{S}{2}\right)^2 + S_s^2}$$

where R is Poisson's ratio, or the ratio of the unit transverse deformation to the unit axial deformation, (about 1/3 for ordinary steel), and the *true* stress P_1 is tension if S is tension, and compression if S is compression.

* * *

MANGANESE INDUSTRY IN AMERICA

There has been a great reaction in all the "war mineral" industries during the past year. There were many minerals that became valuable only because of their uses in connection with the manufacture of war materials, and many industries grew up in the effort to supply these minerals. As soon as the demand for war material ceased, these overgrown or newly established industries faced a serious condition. The manganese industry was one of these. During the first nine months of 1919 the production of manganese ore containing 35 per cent or more manganese was only 53,800 tons as compared with 229,900 tons, or more than four times as much, during the corresponding period in 1918. During the last three months of the period mentioned in 1919, less than 10,000 tons were produced, which indicates the tremendous falling off in the industry.

The cost of mining manganese in the United States is much higher than the cost in foreign countries, and the grade of the domestic ore, in general, is lower than that of the foreign ore. Hence, production of manganese ore can be expected in the United States only in case there is a high protective tariff on this mineral. An effort is now being made to obtain a tariff which will give this industry an immediate prosperity, but it is stated by the United States Geological Survey that in a few years of normal steel production—four or five years at the most—the known manganese resources of this country will be exhausted. In the event of another war after the domestic manganese deposits had thus been practically exhausted, or at least seriously depleted, the country would face a much greater shortage than it did in 1917 and 1918.

* * *

The scarcity of coal in France has again brought the question of the use of the Alpine water powers to the forefront. In the Alpine region 6,000,000 horsepower can be developed by the average water flow, and elsewhere in France 3,000,000 horsepower can be obtained by hydraulic development to various streams. At the close of 1915, 738,000 horsepower had already been developed from installations in the Alps, but this amount has been considerably increased during the war period.

The Machine Tool Trade

REPORTS from machine tool builders both in New England and in the Middle West indicate continued activity. The foreign trade has been considerably curtailed by the present condition of the foreign exchange, but the domestic trade has so far absorbed all the capacity thus made available for the home market. Some machine tool builders in the middle western states were temporarily affected by the coal shortage due to the miners' strike and the orders for shutting down industrial plants that followed; but the strike now being practically settled, the industry has resumed its activity. There have been some further increases in the prices of certain types of machine tools, and in some instances prices are now quoted that are higher than the prices during the war period. This refers particularly to certain lines of machine tools, the advances on which during the war period were very moderate and a considerable percentage less than the general advances in the cost of raw materials and labor.

The scarcity of steel is making itself felt, and higher steel prices are anticipated. This increase in price is a direct result of the disorganized conditions in the steel trade caused by the strike. As steel advances in price, the products made from steel will doubtless also advance, and this, in turn, will affect the products manufactured by machinery, and consequently increase the cost of living; so that further advances in living costs may be anticipated as a direct result of the strikes in the steel industry and in the coal mining field. Foreign makers of high-grade steels—high-speed and tool steels—are active in introducing their products into the United States or in pushing the sales of brands already introduced, the conditions of the foreign exchange as well as the state of the steel market here both being favorable to this. It is even reported that European-made small tools will soon be placed on the market in the United States, because with all European money worth only from 45 to 80 per cent of its normal value, it is possible to pay transportation charges and tariff duties, and yet sell at a price lower than that now prevailing in the American market. The only way that these conditions can be remedied is by stabilized labor and increased production, matters which are very largely in the hands of labor itself. An educational campaign is needed to thoroughly impress the whole nation with the fact that prosperity is based upon goods produced and can be had in no other way.

EXPORTS OF METAL-WORKING MACHINERY FROM THE UNITED STATES, OCTOBER, 1919

Countries	Lathes, Dollars	Sharpening and Grinding Machines, Dollars	Other Machine Tools, Dollars	All Other Metal-Working Machinery, Dollars
Austria-Hungary	.....	.....	.....	64
Belgium	68,215	45,238	6,666	146,565
Denmark	1,034	620	3,760	29,452
Finland	.....	1,902	4,685	.....
France	263,383	106,416	200,487	1,496,506
Germany	.....	272	.....	6,980
Italy	17,549	16,806	45,943	117,305
Netherlands	2,035	1,334	4,049	9,116
Norway	7,144	3,123	16,853	14,773
Portugal	2,125	225	1,589	1,023
Roumania	4,866	.....	.....	.....
Russia in Europe	.....	.....	571	.....
Spain	31,204	25,084	29,241	86,538
Sweden	14,948	23,421	14,842	21,558
Switzerland	.....	475	10,549	1,385
England	167,868	80,272	236,221	457,495
Scotland	.....	.....	48,804	779
Canada	30,893	122,795	149,003	181,432
Costa Rica	.....	.....	1,038	.....
Guatemala	1,320	36	.....	.....
Honduras	3,933	.....	.....	2,959
Nicaragua	.....	.....	499	.....
Panama	2,858	206	241	4,135
Salvador	.....	20	.....	.....
Mexico	1,042	498	7,330	5,663
Newfoundland and Labrador	31	.....	67	336
Barbados	20	.....	.....	5,477
Jamaica	899	.....	304	.....
Trinidad and Tobago	1,725	837	32	.....
Other British West Indies	.....	4	.....	.....
Cuba	35,173	2,208	42,306	21,151
Danish West Indies	.....	22	.....	.....
French West Indies	.....	.....	414	.....
Dominican Republic	.....	.....	320	.....
Argentina	8,553	566	7,723	11,427
Bolivia	.....	.....	228	195
Brazil	18,804	456	12,234	5,575
Chile	7,140	689	3,235	42,525
Colombia	.....	43	161	1,814
Ecuador	.....	96	271	2,253
British Guiana	.....	.....	520	.....
Peru	928	141	877	9,772
Uruguay	.....	.....	912	2,461
Venezuela	1,950	.....	270	.....
China	8,752	574	2,107	13,085
Japanese China	.....	.....	.....	270
Chosen	.....	.....	285	259
British India	6,969	7,521	2,895	8,871
Straits Settlements	.....	70	595	37
Other British East Indies	.....	.....	40	.....
Dutch East Indies	5,105	1,224	9,628	8,677
Hongkong	421	.....	252	282
Japan	26,191	17,329	21,248	74,619
Russia in Asia	18,981	400	15,148	6,791
Siam	.....	56	53	130
Australia	7,407	857	11,841	82,248
New Zealand	650	2,355	2,776	4,758
French Oceania	.....	30	.....	.....
German Oceania	.....	.....	.....	10
Philippine Islands	9,738	210	3,369	3,834
Belgian Kongo	.....	.....	160	.....
British West Africa	960	176	.....	870
British South Africa	3,100	3,741	4,826	5,573
Morocco	.....	.....	.....	85
Portuguese Africa	.....	85	413	.....
Egypt	1,050	530	.....	665
Total	784,964	468,963	927,881	2,897,778

Machinery

Bulletins on Government Machine Tool Sales

The Machine Tool Section, Office of the Director of Sales, War Department, has prepared and is now distributing to dealers and users of machine tools through the various district selling offices of the War Department, a comprehensive bulletin, listing approximately 2500 machine tools, valued at about $4,000,000, which the government is offering for sale. The machine tools are listed in the bulletin according to their class, type, size and maker, together with the address of the district office having the tool for sale. A brief description of each tool is given, including its "service condition." This bulletin will be revised from time to time as sales are made or as additional machines are declared surplus. It is expected that new bulletins will be issued every fifteen days. Copies of this bulletin may be obtained from the following bureau district offices: Air Service, Materials Disposal Branch, at 811 Little Bldg. Boston, Mass.; 2050 Elmwood Ave., Buffalo, N. Y.; 230 E. Ohio St., Chicago, Ill.; Maxwell Motor Co., E. 1st St. and B. & O. R. R., Dayton, Ohio; Aviation General Supply Depot, Springwells, Detroit, Mich.; 360 Madison Ave., New York City; and Postal Telegraph Bldg., San Francisco, Cal. Copies may also be obtained from the Ordnance Salvage Board at Columbia Ave. and B. & O. R. R., Baltimore, Md.; 19 Portland St., Boston, Mass.; 945 Main St., Bridgeport, Conn.; 74th and Ashland Ave., Chicago, Ill.; and Walsh Bldg., 3rd and Vine Sts., Cincinnati, Ohio.

Government Machine Tools Sold to France

The War Department, with a view to assist in the rehabilitation of French industries, particularly those located in the devastated regions of France, has entered into a contract with the French Republic, under the terms of which the French government will purchase $25,000,000 worth of machine tools from the surplus stock of such tools held by the

War Department in the United States. The French government will pay for these machine tools with ten-year, 5 per cent bonds of the French Republic, which at maturity, are payable in dollars. The French government has appointed a commission consisting of ten members who have already left France to come to the United States for the selection of the machine tools. These representatives will select the tools to be purchased, and the French government is to accept them at the point of their present location and in the condition in which they now are. The tools purchased under this contract will be paid for at prices determined by the price-fixing chart adopted by the War Department last summer for arriving at prices to be charged for surplus machine tools.

Exports of Metal-working Machinery

The accompanying table shows exports of metal-working machinery, in general, and of machine tools during the month of October, 1919, which is the latest information published by the Department of Commerce. The effect of the depreciation of the foreign exchange had not made itself felt at this time, and the total exports of metal-working machinery amounted to over $5,000,000, out of which a sum of nearly $2,200,000 was represented by machine tools, corresponding to an annual rate of machine tool exports of over $26,000,000. France was the leader in imports of machine tools, having taken a total of about $570,000. England takes second place with imports amounting to nearly $500,000. During October, Germany entered the field as a buyer to a very small extent, the exports of metal-working machinery to Germany amounting to slightly over $7000. The exports to the Scandinavian countries decreased appreciably, not only because of difficulties with exchange, but also because of the very low prices at which German machine tools are offered in the Scandinavian market.

Causes of Depreciation of Foreign Exchange

The causes that have brought about the demoralized condition of the foreign exchange are many. In the first place, during and after the war there were huge increases in our exports to Europe, while there was a great decrease in our imports. Hence there came into the foreign exchange market a greater volume of checks and drafts on Europe than European drafts on America, resulting in a far greater supply of foreign exchange in this market than there was a demand on the part of Americans having remittances to make abroad. As always happens in the case of any commodity when supply exceeds demand, prices of the foreign exchanges fell. The depreciation of foreign exchange in the American market, therefore, is merely a normal expression of the law of supply and demand, and normal conditions can be expected only when our imports become large enough in proportion to our exports to stabilize the foreign exchange market.

During the war the foreign exchange on Europe was kept from depreciation to present levels by the great volume of gold sent from Europe to the United States in cash liquidation of the adverse European balance, and later, when America entered the war, our Government extended credits to our allies which kept a large volume of foreign exchange for European purchases out of the market. Now, however, Europe has practically sent here all the gold that can be spared, and the extension of government credit has ceased. Hence, there is nothing to prevent the foreign exchange from dropping to a low level from which it will return only as trade begins to flow from Europe to this country as well as in the opposite direction.

In addition to this, European exchange is further depreciated by the fact that foreign currencies are depreciated because of great issues of paper money by practically all of the European nations—certainly by all those engaged in the war. The redemption of these issues and the restoration of an actual gold standard in Europe will aid in correcting the depreciation of European currencies.

FOREMEN'S MEETINGS

By OSCAR E. PERRIGO
Pratt & Whitney Co., Hartford, Conn.

There has lately been a great deal of interest in foremen's meetings, shop committees, and similar plans for increasing the efficiency of manufacturing plants and creating a better understanding between employers and employes. The question of where and when this movement started and its progress up to the present time has been referred to by many writers. It is the object of the present article to add a few paragraphs to the history of this movement.

In the autumn of 1888 the writer was engaged to design special tools and machinery for the American Graphaphone Co., which had some time before taken over the principal building of the Elias Howe Sewing Machine Co. in East Bridgeport, Conn., for the purpose of manufacturing the graphaphone invented by Professor Taintor. In February, 1889, the writer was made superintendent of the factory, and it was shortly after that time that a plan was worked out for foremen's meetings. The factory building was long and comparatively narrow and contained several floors so that communication between the different departments and the superintendent's office was not very prompt or satisfactory. The first step toward a more systematic method of dealing with the foremen was to divide the day in such a manner that each class of business requiring the superintendent's opinion would be handled at a particular time. Requisitions and reports were presented from 8 to 9 in the morning; conferences with the two assistant superintendents were held between 9 and 10; the different departments in the shop were visited between 10 and 12; reports were again presented between 1 and 2, and a conference with the general manager was scheduled at 2 P. M.; the time between 5 and 6 P. M. was again spent in the shop. The working hours were from 7 to 12 A. M. and from 1 to 6 P. M. for five days in the week. On Saturdays the closing time was one hour earlier, or at 5 P. M., making a fifty-nine-hour week.

While this plan of dividing the time was an improvement upon the older custom of trying to "take things as they come" it was soon discovered that things often "came" much faster than they could be taken care of, and that some better plan was desirable. This resulted in a scheme in which, instead of "going after the foremen," the superintendent had the foremen come to him. In this way what came to be called the "Foremen's Meeting" was organized. This meeting was held at 2 P. M. each day except Saturday, and was conducted as follows: The two assistant superintendents and the foremen were seated in the superintendent's office with a stenographer ready to take notes. "Complaints" were first in order, and each foreman was called upon, in turn, to present his difficulties. The other foremen were encouraged to give their opinions as to how the matter could best be handled. Then the assistant superintendents gave their opinions, and the superintendent finally gave such orders as seemed to meet the requirements in each case.

The next question in order was "troubles," which related generally to jigs or fixtures, or methods of performing certain machining operations. Usually several suggestions were offered by the other foremen, sometimes shedding a new and unexpected light on the matter, after which a final decision was made as before. Finally came "recommendations," which were handled in a similar manner. The superintendent and the assistant superintendents then made some general remarks relating to the progress of the work or asked for any needed information concerning it, after which the meeting closed. These meetings usually lasted from forty minutes to an hour. What had been said was written out and a copy handed, during the afternoon, to each man present at the meeting.

At the time these meetings were organized the writer had never heard of foremen's meetings. Generally speaking, more ideas are brought out by bringing men together in a meeting than by approaching the same men singly.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

Hartness Screw Thread Comparator. Jones & Lamson Machine Co., Springfield, Vt. 467
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Hartness Screw Thread Comparator

The Hartness screw thread comparator is a projection type of apparatus designed to show instantly the magnitude and kind of errors in screw threads. When the thread shadow is projected upon the standard tolerance chart, the relative positions of the shadow and chart not only show the resultant effect of lead errors, the pitch diameter, the finish and form of the thread, but also whether the tolerance is within the limits that are required in interchangeable manufacture.

WHILE the projection lantern has been used for sometime for inspecting screw threads of various kinds, it has been applied generally to the finer work, such as the inspection of thread gages and precision screws. The Hartness screw thread comparator, now manufactured by the Jones & Lamson Machine Co., Springfield, Vt., combines new features that make it possible to see instantly the resultant effect of all elements that affect the fit of a screw thread. This projection apparatus not only provides a means of determining in a practical way, the magnitude and kind of errors in screw threads, but enables screws of various classes to be inspected on the basis of dependability. Since a dependable screw fastening is one having a known depth of engagement of the threads of mating parts and a fairly uniform distribution of stress over the threads (or in other words, a good surface area in contact) this new basis of measurement is considered essential to the most satisfactory use of screws of various kinds. Screws which are to be dependable, either as a means of adjustment or for fastening purposes, must have well-formed flanks with a reasonable degree of accuracy in lead and pitch diameter. These elements are revealed instantly by the visual method.

This measuring machine, or comparator, is shown in use in Fig. 1. The lantern, work-holder, and lenses are all mounted upon a substantial column, and there is a bench-like frame for holding the tolerance chart upon which the thread shadow is projected. The work-holder contains the projection and magnifying lenses which are selected and designed for screw thread service. In addition, there are condensing lenses in the lamp house. It is neither necessary nor desirable to use this apparatus in a dark room, a moderate light being preferable.

The tolerance chart has two rows of dots, and the space between these rows of dots represents the allowable error for the screw thread. A detailed view of the type of work-holder commonly used for bolts is shown in Fig. 2. The bolt is placed in supporting cradles and it is held in position by a finger which is held lightly against the bolt by the operator's right hand. At the same time, the operator rotates the bolt with his left hand, partly to eliminate any foreign matter that may be on the screw or lodged in the cradles. This rotation of the bolt also reveals the general character of the thread, as regards roundness and "stagger." The thread in the cradle is cleared at the crest and root so that it bears on the sides of the thread being inspected, thus locating the work in relation to the flanks of the thread.

The machine is adjusted by the use of a standard threaded plug that is selected with reference to the particular work being inspected. The work-holder just referred to is the design used for most bolt work when the thread is comparatively short, and there is a cylindrical part that may be used as a supporting surface. When inspecting long screw threads, it is sometimes desirable to use two threaded "nests" or cradles, in which case only one of them is fixed and the other is allowed to slide parallel to the axis of the screw, to compensate for lead errors. A work-holder having two threaded cradles is shown in Fig. 3. One

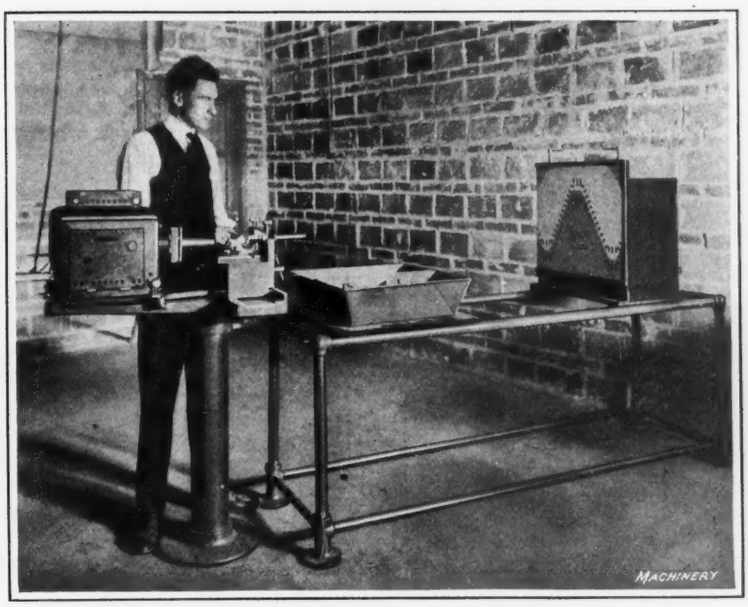


Fig. 1. Hartness Screw Thread Comparator consisting of a Projection Lantern and a Tolerance Chart upon which the Thread Shadow is projected

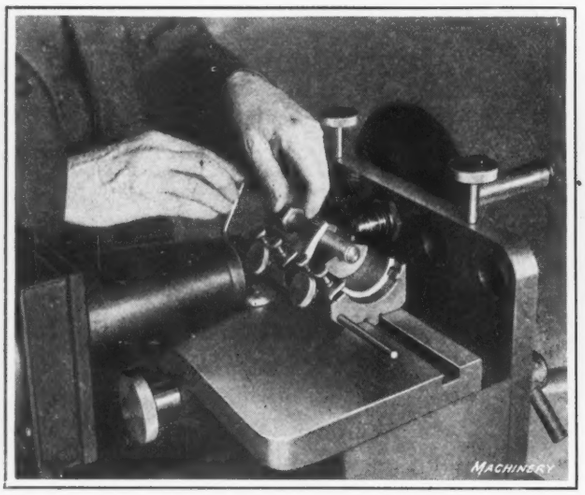


Fig. 2. Work-holder of the Form generally used for Bolts

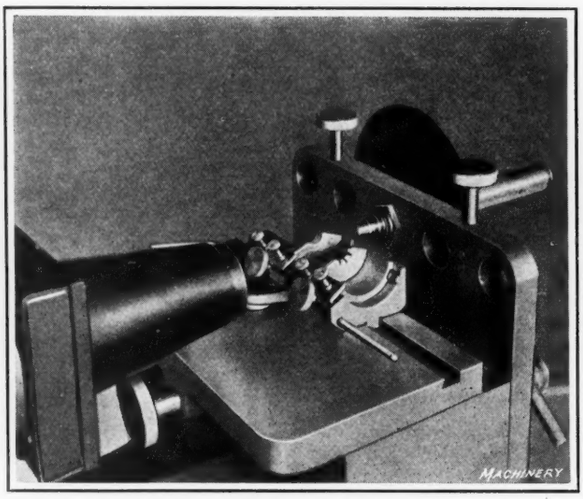


Fig. 3. Work-holder for Screws—Note the Two Threaded Cradles

of these cradles is clamped rigidly in position and the other is free to slide endwise. The fixed cradle is located at a distance from the projecting lens equal to the length of engagement of the screw, either in a nut or threaded hole. This location of the fixed cradle determines the extent to which the shadow will be shifted sidewise on the tolerance chart.

When the shadow of the thread to be inspected is projected upon the chart which has been adopted as a standard for that particular class of work, the position of the shadow relative to the two rows of dots representing the maximum and minimum sizes, shows errors in diameter, lead, angle, and contour. For example, when the shadow lies along the lower edge of the upper row of dots, this shows that the screw is of maximum size. On the contrary, if the screw is of minimum size, its shadow will coincide with the edges of the lower row of dots. Thus, the space between the dotted lines represents the range of variation in size that will be tolerated for the grade of work represented by the chart. Hence, the shadow of each screw tested must lie between these boundaries.

Since the lead error directly affects the apparent fit of the screw in the threaded hole, it has been found desirable for the average better grade of work to allow any lead error that will not shift the shadows outside of these boundaries. The shift of the shadow sidewise is due to the amount of lead error between the thread that rests in the thread nest and the thread that is projected on the chart. The distance between the threads referred to, for the average requirement, should equal the length of engagement of the thread in service. In the case of a bolt thread that is used with a nut, this length is made equal to the thickness of the nut. If a cap-screw, then the length should equal the length of thread that is engaged in the threaded hole. For the average run of work, the length of engagement may be considered equal to one and one-half diameters. If both the screw and nut are to be hardened, then this length must be fully equal to the length of engagement. If either or both the screws and nut or threaded hole are to be soft then for some grades of work a shorter length may be acceptable. The important point to be emphasized is that the lead plays a very important part in the fit of a screw and its importance varies with the class of service. The comparator makes it possible to gage screws within any degree of precision of lead that the work requires. Lengthening the distance between the threaded nest and the projecting lens increases the precision any amount desirable within the length of the screw.

Tolerance charts are easily made to suit different classes of work. By a comparison of the tolerance chart and shadow illustrated in Fig. 4, it will be seen that this particular thread has an error in lead, as the shadow is displaced to the left. Another example is shown in Fig 5; in this case the projected thread is very accurate as to lead, and its pitch diameter is the minimum size, as indicated by the fact that the shadow coincides with the inner row of dots on the tolerance chart. This screw and the one previously referred to is a U. S. standard, having a nominal diameter of $\frac{5}{8}$ inch. Since it is magnified two hundred times, the slight surface imperfections are readily seen when the image is projected on the chart. It will be noted that the root or bottom of the thread profile is rounded somewhat as the result of wear on the cutting dies. As there is seldom a full thread in the nut or threaded hole, this rounding can be tolerated.

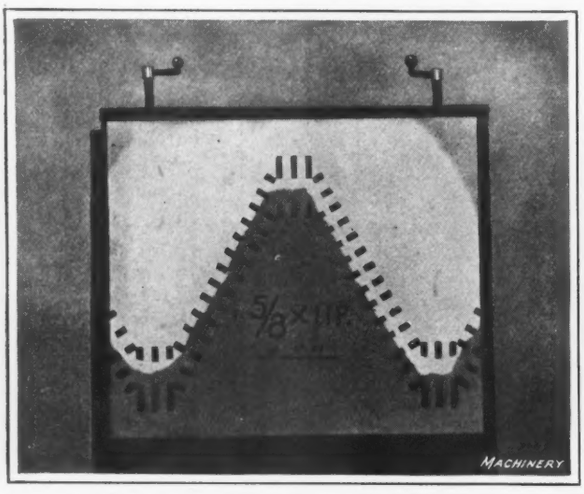


Fig. 4. Tolerance Chart and Shadow of Thread which has a Lead Error

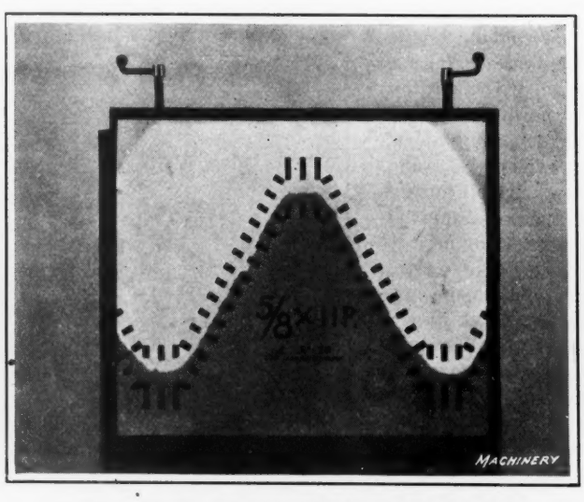


Fig. 5. Shadow of Thread of Minimum Pitch Diameter

This comparator reveals the essential characteristics of the thread, and indicates to what extent the thread surface will be in contact with a normal mating part. It has been found that screws measured before and after being subjected to wrench stress are materially different, which illustrates the accuracy and practical value of this visual method of testing, which not only shows the resultant effect of lead errors, the form of thread, the pitch diameter, and the smoothness of surface, but includes the tolerance measurement that insures interchangeability. This apparatus, unless otherwise specified, is provided with cradles and charts for U. S. standard screws varying from ⅜ inch to 1 inch in diameter.

"ROCHESTER" SAFETY SHAFT OILER

The Ricker Mfg. Co., 239 N. Water St., Rochester, N. Y., has recently developed a device known as the "Rochester" safety shaft oiler. It consists of two principal parts, namely, an oil-containing cylinder and a displacing plunger. The device is held in position at one side of a shaft hanger by means of a ⅜-inch iron suspension rod, the upper end of which is in the form of a hooked flange inserted beneath the regular lag screw that supports the hanger. An oil displacing plunger is mounted on an upright and operated by an 18-pitch traversing screw that runs in lugs cast integral with the two parts of the oiler. At the bottom of this screw, there is a wing-nut which is engaged by a socket at the end of a pole of sufficient length to enable the attendant to manipulate the oiler from the floor. In this way, danger of accidents is avoided by making it unnecessary for men to climb ladders to reach the bearings of moving shafting.

"Rochester" Safety Shaft Oiler made by the Ricker Mfg. Co.

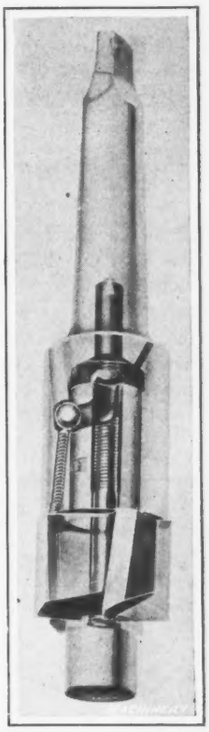
From the upper part of the oil container, two copper tubes emerge and lead to the oil-holes on either side of the bearing. To force oil from the container into the shaft bearing, it is only necessary to engage the wing-nut on the traversing screw with the forked pole and give the traversing screw one complete turn. This furnishes the desired amount of oil to the bearing, and the oiler contains a sufficient quantity of lubricant to last for one year. The oiler is furnished complete with a fork for the operating pole. In addition to the safety feature, it is claimed that this lubricator is the means of saving time, as the necessity of carrying ladders through the plant is eliminated; also, provision is made for supplying the correct amount of oil to the bearing without having a surplus dripping on the floor.

"BABBITTRITE" COMPOUND

"Babbittrite" compound has recently been placed upon the market by the Products Sales Co., 606 Security Bldg., Milwaukee, Wis., to be used in place of clay or putty that is frequently employed to hold babbitt metal while pouring journal boxes. Advantages claimed for this compound are that it is always ready for use because it does not show a tendency to harden when exposed to the air or to heat, and it is unnecessary for the compound to be worked or mixed in any way to prepare it for use. It is also claimed that when using this compound in babbitting a bearing, it is impossible to produce what is termed a "blow-out," because "babbittrite" does not absorb moisture and will adhere to the work under all conditions. Attention is called to the fact that the compound can be used over and over again, the same compound being suitable for use at least 100 times. In addition to the saving made possible in this way, there is a reduction in labor cost resulting from the fact that the compound is always ready for immediate use without mixing.

GAIRING COUNTERBORE

In the accompanying illustration there is shown a phantom view of a counterbore which is now being manufactured by the Gairing Tool Co., Inc., Detroit, Mich., and this illustration shows all features of the tool so clearly that only a brief description of the counterbore will be necessary. A hardened ball retains the cutter in place when either in a working or idle position, and also drives it. To release the cutter from the holder, it is necessary to turn it to the left, thereby compressing the spring and releasing the ball from its seat. The floating ball supported by spring tension adjusts itself so that the shoulder of the cutter remains squarely against the end of the holder which supports the cutting thrust, while the ball in its pocket prevents backlash of the cutter and eliminates chatter. A split nut holds the pilot in place, and where it is necessary to bore two or more holes and at the same time perform a spot-facing operation, a multiple tool is required. In such cases, the type of pilot which is used on this counterbore allows the nut to hold the cutters intact.

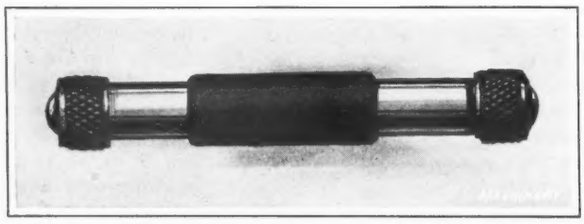


Counterbore made by the Gairing Tool Co., Inc.

The body of the holder is free of obstructions on its outer surfaces, which is an important factor in providing for the safety of the operator. Holders of this type are made in sizes known as Nos. 1, 2, 3, and 4, and they will take any sizes of cutters from ¼ to 3 inches. Sets of these spot-facing tools are made up to meet the requirements of various classes of work. For instance, there is a No. 2 fillister-head and flat screw set, which makes a useful combination of tools for use in jobbing shops, tool-rooms, and certain manufacturing plants. It includes two flat-head screw countersinks and a counterbore for each size of standard fillister-head screw from ¼ to ⅞ inch, inclusive; also a No. 2 holder which accommodates all of the cutters, and a wrench to fit the special pilot nut. As an example of one of the more complete sets, there is the No. 5 which comprises two countersinks, fifteen cutters, thirty-eight pilots, three holders, and an assortment of pilot nuts and wrenches. These more complete sets are adapted for use in large manufacturing plants.

INSIDE GAGES

For use in gaging the inside of cylindrical and other shaped work where the accuracy must be within 0.0001 inch, the Production Equipment Co., Inc., 1 Madison Ave., New York City, is selling a line of inside gages in which hardened steel balls are used for the contact points. These balls fit into sockets at the ends of the gage and are held in place

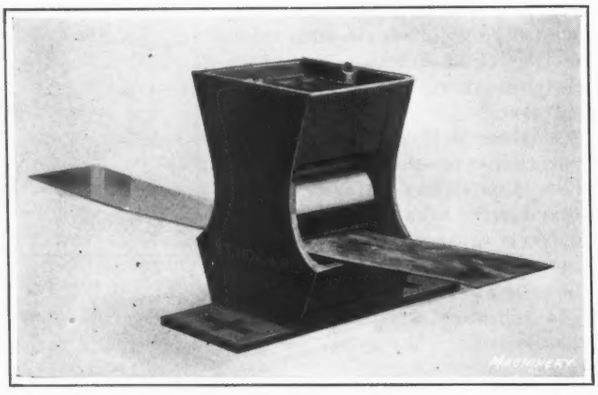


Inside Gage sold by the Production Equipment Co.

by caps which afford a positive method of clamping and still allow the balls to be turned if necessary, so that as soon as there is the slightest indication of wear at points where the balls have been used, the caps are loosened and the balls turned to new positions. It is on account of this method of adjustment that the name "never wear" has been applied to the gages. Another advantage claimed for gages of this type is the degree of accuracy with which the ball centers adapt themselves to the work. It is stated that they automatically find their own centers. Each gage is furnished with a rubber insulation which prevents the heat of the hand from being transmitted to the gage and affecting its accuracy. The gages are carried in stock in all sizes from 1 to 12 inches, and other sizes will be made to special order.

STRIP STOCK OILER FOR POWER PRESS

To provide for lubricating strip stock which is being fed to the dies mounted on a power press, the Practical Device Mfg. Co., 257 Layton Blvd., Milwaukee, Wis., has developed an automatic lubricator which effects a substantial saving in the amount of oil required for this class of service, and also saves time which the operator would otherwise spend in swabbing oil on the metal by hand. In addition to these two possible economies, several other beneficial conditions of operation are claimed by the manufacturers of this equipment, among which are the facts that an excess



Lubricator made by the Practical Device Mfg. Co. for oiling Strip Stock fed to Dies on a Power Press

of oil is not applied to the work and that the lubricant is uniformly distributed so that the best possible conditions of operation are attained. These conditions assist in keeping the press-room floor clean and in increasing production; also, no time is lost by having machines idle while the operator is swabbing oil on the stock by hand. The device consists of a single casting which forms upper and lower oil receptacles separated by a pair of steel rollers, between which the stock is passed. This lubricator may be used either directly on the punch press or as a separate equipment, and the rollers may be driven, if so desired. It will be apparent from the illustration that the design of this lubricator is simple and all of the parts are liberally proportioned, so that there is little possibility of a breakdown. Various sizes of lubricators of this type are made to meet the requirements of different classes of work. An oiler of this kind could also be used on wire working and other types of machinery.

CHICAGO BALL BEARING PULLEYS

For use in transmitting power to grinding machines, buffing lathes, swing saws, and other classes of high-speed machinery, the Chicago Pulley & Shafting Co., 32-38 S. Clinton St., Chicago, Ill., has recently developed a line of driving pulleys, clutch pulleys, and countershafts which are fully equipped with S K F ball bearings. Fig. 1 shows a partial cross-sectional view of the driving pulleys and clearly illustrates the arrangement of both the ball bearings with which this equipment is provided, and the way in which tight and loose pulleys and the large driving pulley are constructed.

A drive of this type is employed with a stationary shaft

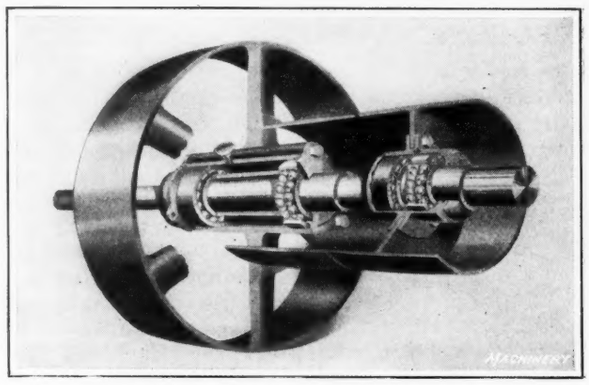


Fig. 1. Ball-bearing Driving Pulley manufactured by the Chicago Pulley & Shafting Co.

and it may be used to advantage in cases where it is desired to utilize an existing countershaft without the necessity of additional millwrighting. Where this plan is followed, the ball bearings are slipped over the shaft, after which the hanger boxes are tightened so that the shaft cannot turn. It will be apparent from the illustration that one of the small pulleys is secured directly to the driving pulley, while both of the small pulleys and the driving pulley are loose on the shaft. In order to transmit power to the machine it is merely necessary to shift the belt to the small pulley attached to the driving pulley. Fig. 2 shows a countershaft equipped with the type of pulleys that are illustrated in Fig. 1.

In Fig. 3 there is shown the friction clutch type of pulley. Important features claimed for this pulley include the ease with which it may be installed, its simplicity of construction and the fact that the pulley occupies very little space on the shaft. It will be evident to all engineers and mechanics who have had experience with the application of ball bearings, that several noteworthy advantages are secured through the use of S K F bearings in the overhead works for driving machine shop equipments. Obvious among these are the facts that ball bearings are practically free from frictional resistance, so that very little power is needlessly wasted; and if bearings of this type are properly cared for, they are also practically free from wear. The pulleys are so designed that provision is made for sealing the ball bearings in a

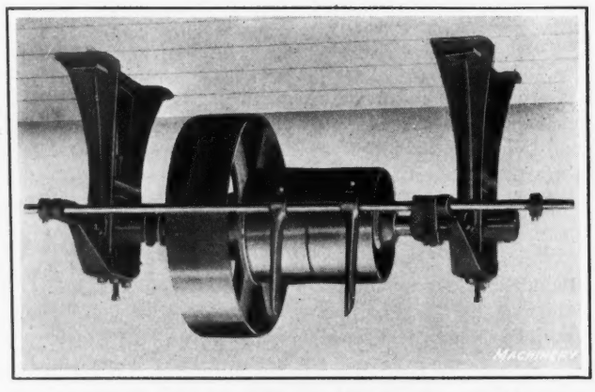


Fig. 2. Countershaft equipped with Driving Pulleys of the Type shown in Fig. 1

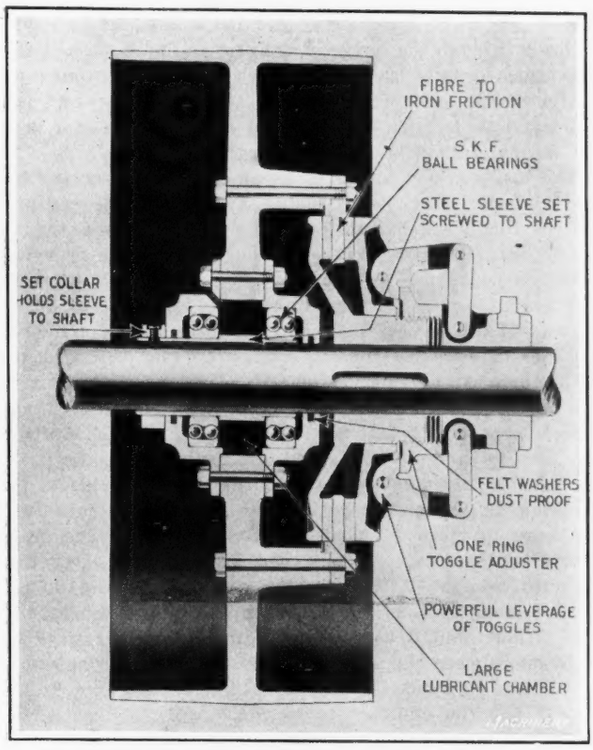

FIBRE TO IRON FRICTION
S K F BALL BEARINGS
STEEL SLEEVE SET SCREWED TO SHAFT
SET COLLAR HOLDS SLEEVE TO SHAFT
FELT WASHERS DUST PROOF
ONE RING TOGGLE ADJUSTER
POWERFUL LEVERAGE OF TOGGLES
LARGE LUBRICANT CHAMBER

Fig. 3. Ball-bearing Clutch Pulley manufactured by the Chicago Pulley & Shafting Co.

chamber which may be filled with a sufficient quantity of lubricant to last for a considerable period of time without requiring further attention. Not only does this simplify the method of lubricating the bearings and save the expense of attendants and lubricating oil, but it also avoids danger of the work being neglected, with resulting bearing trouble.

CRUBAN AUTOMATIC TAPER TURNING TOOL

For use in performing taper turning operations on hand or automatic screw machines or lathes, the Cruban Machine & Steel Corporation, 2 Rector St., New York City, has recently developed a self-contained automatic tool which is here illustrated and described. Tools of this type are made for use on right-hand and left-hand machines and they provide for cutting tapers running from 1/16 to ¾ inch per foot by intervals of 1/16 inch. Two sizes of tools are made which have capacities for handling work of any diameter up to ¾ inch and ⅞ inch, respectively, at the large end of the taper, both tools being capable of handling pieces up to 6 inches in length. Two cutting tools are simultaneously employed, the first of which takes a roughing cut leaving 0.005 inch or less for the finishing tool, in this way imparting a very satisfactory finish to the work. The degree of taper obtained by the tool is governed by a lead-screw and nut, and these two members may be changed without removing the balance of the tool from the machine on which it is being used, so that the substitution of a different screw and nut is the means of providing for cutting a different degree of taper.

An adjustment is furnished to enable work having the given degree of taper to be turned slightly over or under size, according to the requirements of the job, on which the tool is operating. A micrometer adjustment also allows the two cutting tools to be accurately set to produce work of the required diameter. For instance, in setting up the tool for cutting pieces 0.250 inch in diameter at the large end of the taper, a trial cut will be taken after an approximate setting of the tools has been made. Suppose it is found that a micrometer measurement of the work is 0.270 inch; by means of the adjustment, the tools will be advanced 0.010 inch to provide for removing ten thousandths from the radius, thus reducing the diameter of the work to the required 0.250 inch. A micrometer collar is provided on the adjusting screw used for this purpose.

Having made this preliminary statement about the manner in which the Cruban automatic taper turning tool operates, we are in a position to give a detailed description of the arrangement of the mechanism. Regardless of the type of machine on which this tool is used, provision is made for feeding the tool to the work. Referring to Fig. 2, the bar on which the taper is to be turned is shown at *A*. As the tool advances, plunger *B* engages the end of this bar and a continuation of the feed movement causes the plunger and block *C*, by which it is carried, to slide back through the hollow shank of the tool. Secured to block *C* there is a flexible steel band *D* which is wrapped around drum *E* so that as block *C* slides back it pulls band *D* with it and imparts a rotary movement to drum *E*. This drum is mounted on a cross-shaft *F* at the forward end of which there is cut the thread of the lead-screw that fits into the master nut *G*, which is slotted at the side to receive trunnions carried by a yoke *H*. Yoke *H* is supported by a pivot, and at its lower end there is a pin at *I* which enters a slot in the slide *J* by which the two tool bits *K* are carried. The screw *F* occupies a fixed longitudinal position and as it rotates in nut *G*, the nut is caused to move inward thus causing yoke *H* to swing about its pivotal support. This swinging of the lower end of the yoke outward results in drawing back slide *J* at a predetermined rate established by the master lead-screw, which causes the tools to turn the required degree of taper on the work.

Use is made of the regular stops on the machine to control the feeding of the tool to the work, and when the cut has been completed and the tool is withdrawn, a spiral clock spring *L*, the tension of which has been increased by the backward movement of block *C*, causes all members of the tool to return to their starting positions. A simple adjustment is provided to enable the tension of this spring to be regulated, as necessary, in order to assure a prompt and positive return of all parts of the tool to their starting positions. Mention has already been made of the possibility of adjusting the tool to provide for cutting the taper slightly over or slightly under the specified amount. This result is obtained by means of two knurled nuts *M*, one of which is a clamp, while the other controls an adjusting screw that provides for moving pin *I* to a position slightly inside or slightly outside of the position at which it should be located in order to cut a taper of exactly the specified degree. It will, of course, be evident that this result is accomplished by varying the ratio between the distance from pin *I* to the pivot supporting yoke *H* and the distance from the pivot to the pins in yoke *H* that enter slots at the sides of nut *G*.

For setting the tool points to turn work to exactly the required diameter, use is made of a knurled nut *N* carried by an adjusting screw that enters slide *J* by which the tools

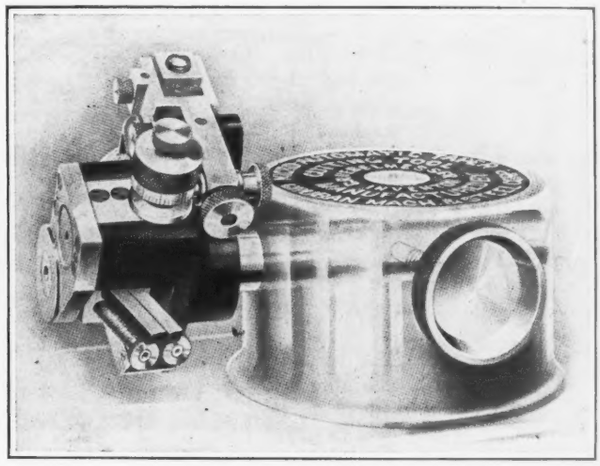


Fig. 1. Taper Turning Tool made by the Cruban Machine & Steel Corporation and sold by the Fairbanks Co.

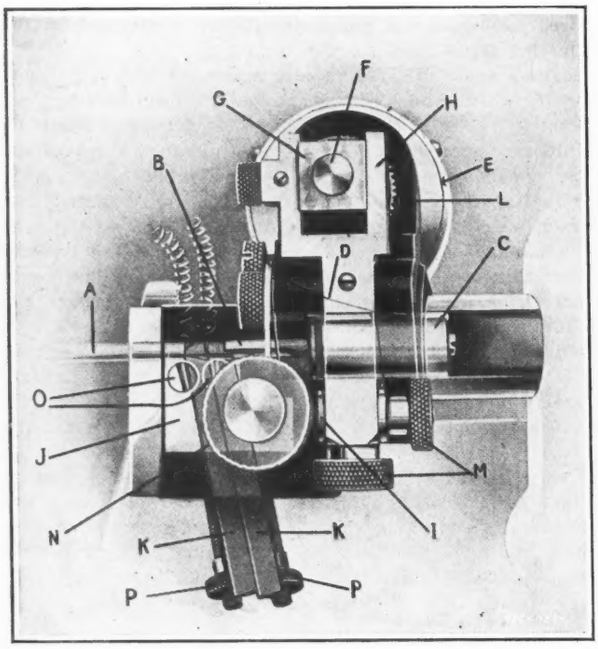


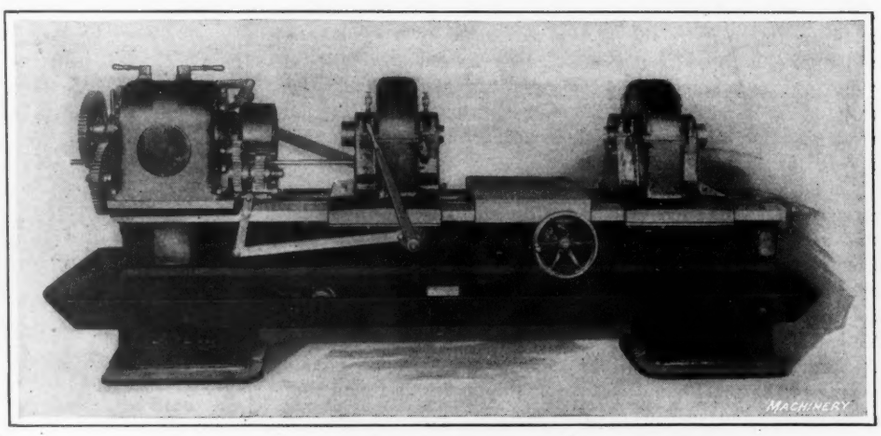
Fig. 2. Partial Sectional View of the Cruban Taper Turning Tool showing Method of Operation

are carried; and there is a micrometer collar provided on this screw to facilitate accurate setting of the tool points in the manner which has previously been mentioned. The tool bits *K* are clamped in place in slide *J* by means of the headless set-screws *O*. Each of the cutting tools has a slot milled in its under side to receive the knurled nuts *P*, and in order to set the tool points in such relative positions to each other that 0.005 inch is allowed for the finishing cut, it is merely necessary to adjust nuts *P* relative to each other before clamping the tools in place by tightening screws *O*. The Fairbanks Co., 416 Broome St., New York City, is the sole distributor of this taper turning tool.

NATIONAL BORING AND TAPPING MACHINE

To meet the requirements of automobile manufacturing plants for a machine adapted for boring and tapping work simultaneously from opposite ends, the National Lathe Co., Cincinnati, Ohio, has recently developed a machine which forms the subject of the following description. Although especially suitable for the requirements of motor car factories, it could also be successfully employed on various other products where there is possibility of supporting the work on a jig plate and having two heads working simultaneously from opposite ends. One lever controls the complete operation of this machine after setting it up for any particular job. By means of this lever, the machine is started and stopped, and the quick return of the heads is obtained in the same way. No manual labor is required to bring the heads into position, except the movement of this lever which controls the power movements. The spindle is made of 50-point carbon crucible steel and has a 1⅜-inch hole extending through it, the front end being turned No. 5 Morse taper. The nose of the spindle has a 1¾-inch slot, ¾ inch deep, milled in it to provide for driving cutter-bars. Carried on the spindle there is a spur gear which is driven by a pinion on a 2 3/16-inch shaft running through the center of the bed, and both of the heads are attached to a lead-screw which also runs through the center of the bed. This screw is threaded right- and left-hand and its location at the center of the bed is said to be the means of affording a very smooth action.

The heads are arranged to swing 24 inches over the bed and 19 inches over the jig plate. A coolant pump and pipe can be furnished, but they are not included as a regular equipment. The gear-box is of the quick-change type and heavily constructed, all changes being made by two levers. The available rates for threading are 10, 12, 16, 20, 24, 32, 40, 48, and 64 threads per inch, and the rates of feed are 0.100, 0.083, 0.062, 0.050, 0.041, 0.031, 0.025, 0.020, and 0.015 inch per revolution. An automatic feed trip provides for disengaging the feed. The speed-box is of the patented forward and reverse type used by the National Lathe Co., which controls the forward and reverse speeds of the spindle. Both are operated by a single lever located at the front side of the machine, in the proper position so that the operator will not have to move from his working position. The quick return of the heads is controlled by the same lever that operates reversal of the machine, and the spindles do not revolve on the return motion. The bed of this machine is 10 feet long, and it has sufficient capacity to take work up to 4 feet between the spindles. The weight is 6000 pounds; but despite this fact, it is claimed that the machine is unusually sensitive and easy to operate.



Duplex Boring and Tapping Machine built by the National Lathe Co.

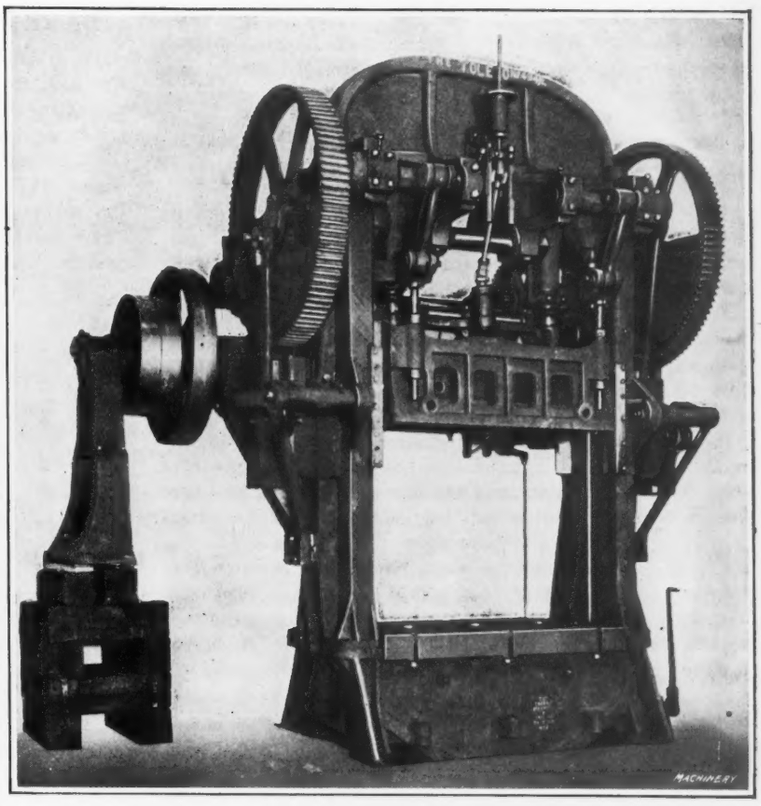
BARRETT THREE-WAY FACING MACHINE

To provide for the simultaneous performance of facing operations on three surfaces of a valve, the Barrett Machine Tool Co., Inc., Meadville, Pa., has recently developed a three-way machine which is here illustrated and described. It will be seen that there are three facing heads that provide for operating on opposite ends of the work and on a surface at right angles to the first two. These heads have a capacity for covering surfaces from 5 to 25 inches in diameter. Each head is provided with a facing block designed to provide for the insertion of cutting tools in two or three different positions. Positive geared feed is provided for the facing blocks through an independent feed-box applied to each housing, the available rates of feed being 1/64 and 1/32 inch in each direction.

The gear-box is mounted at the right-hand end of the main bed and it contains two series of gears transmitting power to the main driving spindles. These gears have ratios of 5.2 to 1 and 20.8 to 1. A single speed countershaft is employed, that is equipped with a friction pulley and a four-step cone pulley. Through the use of this countershaft on the gear-box, eight changes of speed are obtainable to the main driving spindles and facing arms, which afford suitable

cutting speeds while the machine is operating on from the smallest to the largest diameters that it is capable of handling. A cross-table is mounted midway between the pedestal housings, and a suitable chuck is carried on it to provide for holding the work. This table is provided with T-slots, the table being securely bolted to the bed. A hydraulic chucking device, not shown in the illustration, can be supplied, and it is located midway between the front and back housings at the center of the bed.

The front housings close to a minimum distance of 9½ inches between the facing head tools and open to a maximum capacity of 36 inches. The back housing closes to within 5½ inches of the center line of the bed and opens to provide a capacity up to 30 inches from the point of the tool. The facing heads have a radius swing ranging from 2½ to 12½ inches, thus providing a capacity for facing diameters from 5 to 25 inches as previously mentioned. The pedestal housings which carry the facing head equipments are movable in either direction through the use of handwheels transmitting motion through miter gears to the screws. Handwheels are so placed that they are easily accessible for the operator. Power is provided for driving the spindle through spur gearing having a ratio of 5.2 to 1, the power for this purpose being taken from a main driving shaft from which power is transmitted to the cross-shafts through miter gearing.



Double Crank Toggle Drawing and Deep Stamping Press built by the Toledo Machine & Tool Co.

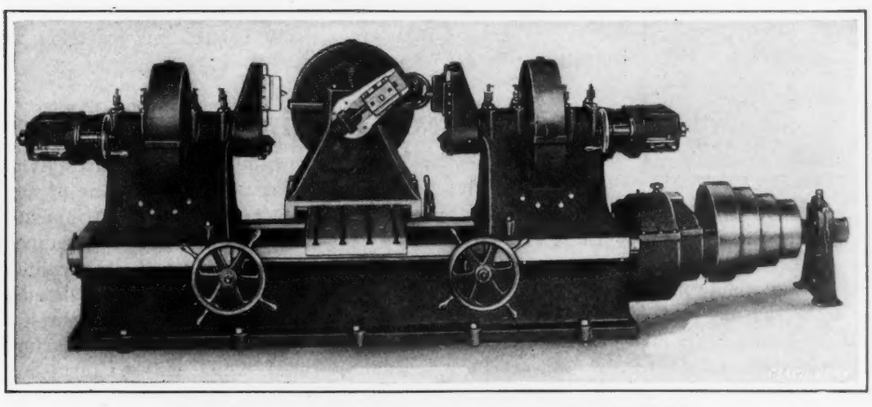
TOLEDO TOGGLE DRAWING AND STAMPING PRESS

The Toledo Machine & Tool Co., Toledo, Ohio, is now building a double crank toggle drawing and deep stamping press which is particularly adapted for use in the manufacture of automobile bodies, crown fenders, hoods, radiators, cowls, engine pans, front seats, rear panels, and for the performance of a variety of other deep stamping and forming operations. The frame of this machine is of this company's four-piece steel tie-rod construction, comprising a base, two uprights, and a crown held together by four large steel tie-rods that are shrunk into place. All of the stress is taken by the four rods. The uprights are heavily constructed to withstand lateral stresses which might occur when the slides are unevenly loaded. It is stated that presses with this type of frame construction are capable of economically operating dies for the heaviest kinds of power press work, such as is met with in automobile construction.

An improved type of blank holder control mechanism is employed, which consists essentially of two complete and independent units combined in a single frame. There are two pairs of rocker shafts operated from each end, which are carried by substantial bearings to withstand the blank holding pressure. The function of this blank holder control mechanism is such that it not only insures an absolutely perfect dwell of the blank holder during the entire drawing operation but also exerts the necessary power; furthermore, the timing in relation to the other moving parts of the press is such as to admit of effective balancing of the entire mechanism, so that smooth running is assured with a press under complete control of the operator.

Very little effort is required to either stop or start the press at any point of its stroke. The entire blank holder pressure is transferred directly to the frame of the press from the straightened toggles. When so desired, provision can be made for conveniently disconnecting the toggle mechanism from the blank holder and attaching the outer slide to the inner slide, thereby converting the press into a single action machine, which adapts it for blanking and forming operations within its capacity. This arrangement is said to be particularly useful when there is not sufficient work to keep the press engaged at all times on the performance of drawing operations. Spring pressure attachments may be fitted in the bed in order to convert the press into a triple action machine.

This company's improved method of supporting the gearing is employed on this machine, for which the features of compactness and rigidity are claimed, allowing a free space all around the press to afford ready access and freedom in handling material. It is the general practice to drive this press by an individual electric motor mounted on a special foundation on the wall or ceiling, the motor being belted directly to the flywheel. Ample die space is provided to take care of the requirements of a wide



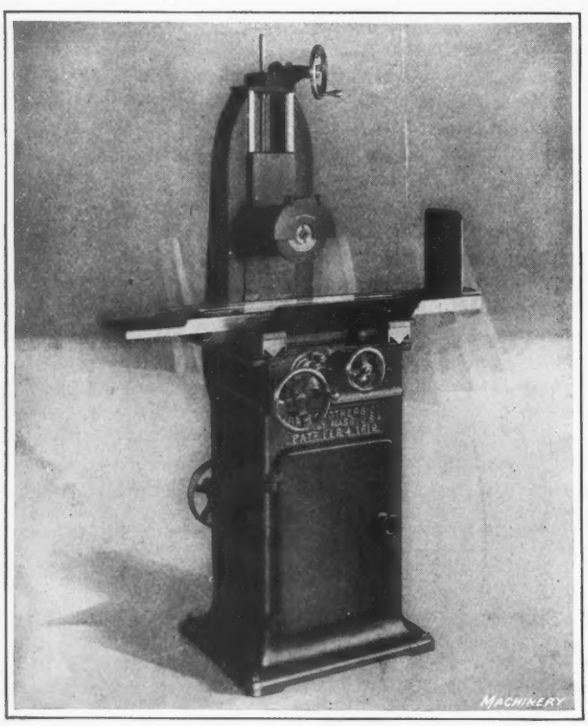
Three-way Facing Machine built by the Barrett Machine Tool Co.

range of work for which a machine of this type is adapted. These presses are made in a number of different sizes to meet the requirements of the various classes of work referred to at the beginning of this article.

REID SURFACE GRINDING MACHINE

In the design of a No. 2 surface grinding machine recently developed by Reid Bros. Co., Inc., Beverly, Mass., there are two features to which the manufacturers call especial attention; namely, the provision of a simple feed mechanism that can be disconnected by a throw-out, and the application of a compact spring curtain that rolls up and unrolls with the travel of the head and keeps the slides free from dust. The head is fitted to the back arm and controlled by a vertical feed-screw. Accumulation of grit and other foreign matter on the bearing surfaces is prevented by the spring curtain just mentioned. Lowering of the head is accomplished by gravity and the downward pull of the belt. Due to its weight and the belt tension, the head simply rests on a plate attached to the elevating screw. This screw does not push the head into the work, but merely permits it to drop and acts as a limit for the head movement. The hardened steel spindle runs in adjustable bronze boxes, and vertical adjustments are obtained by a handwheel graduated to 0.0005 inch.

This machine will take grinding wheels up to 7 inches in diameter by ½ inch face width. The table is 46 inches long by 8 inches wide, with a working surface 18 by 6 inches, and it has three T-slots. Automatic table travel is provided in both directions, and it is controlled by dogs operating against a reversing lever which can be disengaged to permit movement of the table beyond the reversing point without changing the dogs. The quick starting and stopping of the longitudinal feed movement is accomplished by a centralized

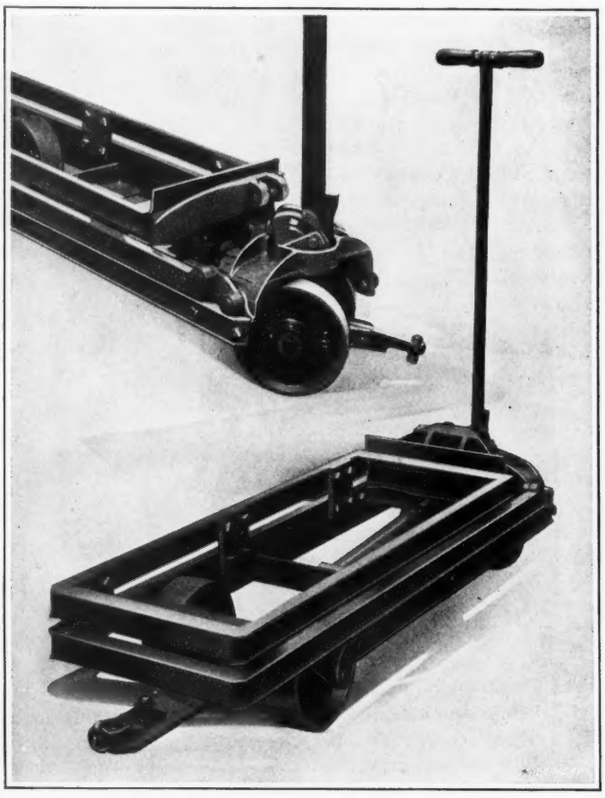


Surface Grinding Machine built by Reid Bros. Co., Inc.

control in the handwheel shaft. The cross-feed is also automatic in both directions, and it has a range of 0.007 to 0.084 inch at each reversal of the table. By a simple movement of an adjusting screw, all of the cross-feed mechanism may be disengaged to facilitate feeding by hand. This machine has sufficient capacity for grinding work up to 18 inches in length by 6 inches in width by 11½ inches in height. It occupies a floor space of 65 by 30 inches.

BARRETT-CRAVENS TRAILER TRUCKS

To provide for their use as trailers behind power units, the Barrett-Cravens Co., 171 N. Ann St., Chicago, Ill., has recently developed a line of trailer trucks which have the elevating feature, so that a trailer can be disconnected from the train and drawn away as an ordinary hand-operated lift truck. These trailer trucks are built in all models in which the lift trucks of this company's manufacture are made. They are available in capacities of 2000, 3000, and 5000 pounds, with carrying frames ranging from 17 ⅝ to 27

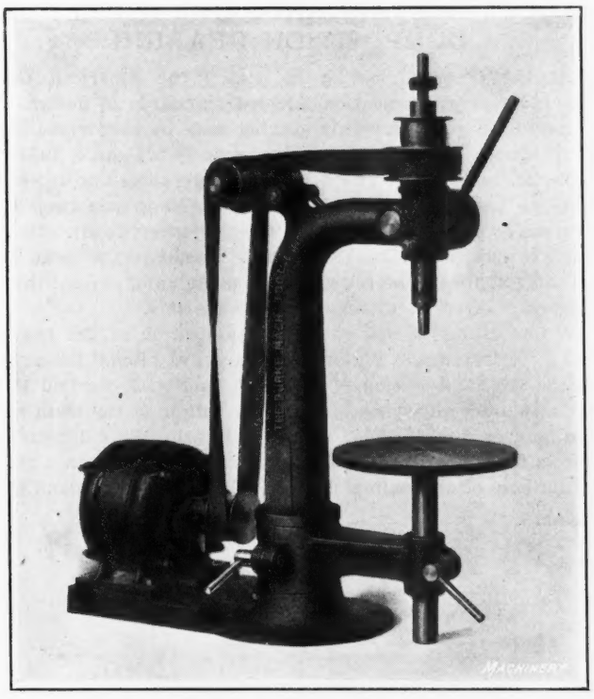


Front and Rear Views of Trailer Trucks made by the Barrett-Cravens Co.

inches wide, and from 30 to 72 inches long. A string of these trailer trucks may be coupled together behind the power unit, and when used in this way the handle of each truck remains erect, being automatically locked in an upright position. Upon reaching the destination, the trucker only has to release the handle and draw the truck away just as he would handle one of ordinary design. Coupling links are furnished at the front and back of each truck, which are made of rolled and flat bar steel, the rear link being directly connected to the rear axle while the front link is built into the turntable in such a way that the ability of the truck to turn through any angle up to 180 degrees is not restricted. Parts may be obtained to equip Barrett-Cravens trucks that are already in use for operation as trailers.

BURKE SENSITIVE DRILLING MACHINE

A No. 1 sensitive drilling machine equipped with individual motor drive has recently been added to the line of machinery built by the Burke Machine Tool Co., Conneaut, Ohio. It will be seen that this drill has a double flanged cone pulley that is mounted on a bearing through which the spindle runs, and the design has been worked out in such a way that there is no pressure on the spindle from the belt tension. The spindle thrust is taken by a ball bearing. A General Electric motor is used, which may be furnished for 110 or 220 volts, 60 cycle, single-phase alternating current, or for direct current of 110 or 220 volts. The spindle



Sensitive Drilling Machine built by the Burke Machine Tool Co.

is tapered to fit a 5/16-inch Almond, Jacobs or a No. 2 ⅜-inch Parker chuck. The drilling capacity of the machine is up to ⅜ inch.

NEW MACHINERY AND TOOLS NOTES

Cutter and Reamer Holder: S. & C. Mfg. Co., Detroit, Mich. A quick-acting holder which is so designed that the tool is held securely and may be quickly released by hand, without requiring the use of a wrench or other mechanical assistance.

Tool-holder: Universal Tool & Mfg. Co., Inc., 680 S. 11th St., Newark, N. J. This tool-holder is convertible to a right-hand turning, left-hand turning, or boring tool, and for that reason it is said to be "universal." Tool bits made from either square or round stock may be used in this holder.

Reversing Gear: Snow & Petrelli Mfg. Co., New Haven, Conn. A reversing gear especially adapted for use in marine work, although it could be adapted for use in any classes of service in machine construction. This gear is built in four sizes with capacities ranging from 9 to 52 horsepower.

Tool Chest: Union Tool Chest Co., Inc., Rochester, N. Y. A mechanics' tool chest, the frame of which is constructed of kiln-dried oak with the joints lock-cornered. It has a tray of similar construction, which is fitted with movable partitions. The top and bottom of the chest are rabbeted, nailed, and glued.

Offset Center Head: A. Verwys Tool Co., 629 Leonard St., N. E., Grand Rapids, Mich. Adjustable offset center head which can be used in connection with a mechanic's scale in laying out squares, hexagons, triangles, and other desired outlines on round work. This tool also finds application in laying out keyseats.

Air-operated Arbor Press: Manufacturers' Equipment Co., Waller & Fillmore Sts., Chicago, Ill. An Arbor press equipped for operation by compressed air. It is made in two sizes, the smaller of which is known as a No. 11 and has a maximum stroke of 6 inches, while the larger press is known as a No. 12 and has a maximum stroke of 7 inches.

Double Punch Attachment: Cleveland Punch & Shear Works Co., Cleveland, Ohio. A double-gagged punching attachment fitted with a spring to lift the punch clear of the material when the gag is withdrawn. Each gag is individually operated and has a long taper, so that when it is inserted the tapered end acts as a wedge and forces the punch stem down.

Tool-holder: Western Tool Mfg. Co., Springfield, Ohio. A drop-forged tool-holder which has a combination wedge and cam locking mechanism for holding the cutter in place. It is stated that the cutter is gripped for its full length and is securely held without danger of slipping. Extremely short cutters can be used in this holder. Holders of this type are made in four standard sizes.

Electric Drill, Screwdriver and Wrench: H. Hollingshead, 55 Liberty St., New York City. A portable electric tool which is adapted for use either as a drill, screwdriver, or wrench. It is furnished with a motor that will run on either alternating or direct current of 110 to 120 volts. Power is transferred from the motor to the spindle through worm gearing carried by ball bearings.

Valve Grinding Machine: D. F. Dunham, 830 W. 37th St., Los Angeles, Cal. A valve grinding machine which is especially adapted for valve facing, although it may be equipped with an extra hub and wheel to provide for grinding small tools. It is driven by a 1/12-horsepower Westinghouse motor that may be connected to any lamp socket, a single snap switch being used to start the motor.

Quenching Compound for Hardening Steel: Wheelock, Lovejoy & Co., Cambridge, Mass. Two kinds of salts for use in making hardening baths. These were developed in Great Britain during the war and were adopted by the British Ministry of Munitions. They are known as "Quenchoid" and "Feusalt," the former being used for hardening carbon steel and the latter for hardening high-speed steel.

Tiering Truck: Elwell-Parker Electric Co., Cleveland, Ohio. A combination truck for transporting and lifting materials and finished product in industrial plants. It is driven by an electric motor which obtains power from a storage battery, the drive being through single reduction worm gearing. A separate enclosed motor, direct-connected to the hoisting drum, provides for operating the tiering hoist.

Crankpin Re-turning Tool: Sawyer-Weber Tool Mfg. Co., 350 S. Alameda St., Los Angeles, Cal. A tool for re-turning crankpins, which may be furnished with different forms of cutters to provide for finishing crankpins of various lengths. The tool is made in four sizes, for pins ranging from 1⅛ to 3 inches in diameter by 1½ to 3 inches in length up to 3 to 6 inches in diameter by 3½ to 7 inches in length.

Profiling Machine: R. M. Clough, 327 Colony St., Meriden, Conn. A small profiling machine for use in cutting dies, stamps, etc. The machine is driven by a ⅛-horsepower motor and the spindle runs in ball bearings. A longitudinal movement of 12 inches and a cross movement of 5 inches are provided for the table, a micrometer dial being furnished on both screws, in addition to a micrometer table stop.

Milling Cutter and Counterbore: New Britain Tool & Mfg. Co., New Britain, Conn. The milling cutter has a body made of mild steel with high-speed steel blades inserted and locked in place by pins which have slightly tapered flat sides to engage the blades. The counterbore has a renewable high-speed steel cutter, while the shank of the tool is made of carbon steel and drives the cutter by the keyway across its end.

Tumbling Barrel: Ideal Concrete Machinery Co., Cincinnati, Ohio. A tumbling barrel which is equipped with an automatic loading device that takes parts from the ground level and discharges them directly into buckets or buggies, without stopping the rotation of the barrel. To prevent overtumbling or insufficient tumbling, the operator can reach in and take out a sample of the work at any time, without interrupting the process.

Self-gripping Mandrel: Efficiency Tool Products Co., Bridgeport, Conn. A self-gripping mandrel which has two sets of three-equidistant grooves that are inclined circumferentially. Carried in each groove there is a roller backed up by a flat steel spring. With a piece of work in place on the mandrel the pressure of the cut forces the rollers up the incline so that the mandrel's gripping power is proportional to the severity of service.

Machine Tool Center: Federal Steel Co., Detroit, Mich. A center adapted for use on lathes and milling, gear-cutting, and grinding machines, and which consists of a high-speed steel center or point carried by a hardened steel sleeve. The sleeve acts as a holder and is not subject to wear, being merely required to support the center in a tapered hole. The point can be entirely removed without requiring the sleeve to be taken out of the machine.

Lifting Magnet: Cutler-Hammer Mfg. Co., Milwaukee, Wis. A lifting magnet which is made rectangular in shape and is adapted for handling iron and steel products including bars, sheets, billets, ingots, pipes, etc. Advantages claimed for the rectangular magnet for this class of work are that the maximum lifting capacity can be obtained for a given weight of the magnet, and that it is possible to attain greater speed in handling the work.

Ellipsograph: Daniel C. Reid, 2717 N. Crosky St., Philadelphia, Pa. An instrument for drawing ellipses, which may be provided with either a pen or pencil which is carried at the end of a slotted bar. If so desired, this bar may be easily removed to allow the remainder of the instrument to be used as an ordinary pair of spring dividers. Ellipses with major axes ranging from 1½ to 12 inches can be drawn at a single operation, and circles up to 12 inches in diameters may also be drawn.

Universal Vise: New Britain Tool & Mfg. Co., New Britain, Conn. A tilting and swiveling vise which is adapted for use on milling and drilling machines, and for laying out work. The important feature of this tool is that it combines means of obtaining any desired angular setting. Any angle within a complete circle may be obtained in a horizontal plane; and from vertical to 10 degrees below the horizontal, in a vertical plane.

Portable Radial Drilling Machine: Multi-Angle Drill Corporation, 1 W. 34th St., New York City. A machine adapted for use in connection with any standard electric, pneumatic, or hydraulic drills, although such tools are not furnished as a regular part of the machine. The drill is carried by a radial arm supported by the column which also carries the usual form of round table. The whole machine is mounted on a truck for portable service.

Keyway Cutter: V. E. La Point Mfg. Co., Manchester, Conn. A series of keyway cutters which are intended for use on arbor presses or similar machines, although they could be driven through holes in the work with a soft hammer. One pass of the tool through the hole finishes the keyway. The body of the tool is of the diameter of the hole in which the keyway is to be provided, and the cutters are for keyways of standard size.

General-purpose and Welding Goggles: T. A. Willson & Co., Inc., Reading, Pa. Two types of shop goggles, one of which has aluminum cups fitting over the eyes, that can be furnished with either plain or colored glasses, and may be without ventilating perforations if it is desired for them to be dust-tight. The other goggles have lenses which are "dropeye" in shape and are made of colored glass to afford protection against rays from welding torches.

Drill-holder and Friction Chuck: Roberts Mfg. Co., 152 Brewery St., New Haven, Conn. This holder provides for driving drills with twisted or mutilated tangs by driving at the large end of the shank. The drill is secured in place in the holder by turning a knurled collar by hand. The friction chuck of this company's manufacture is of simple design and is said to be positive in operation. It is adapted for driving taps and can be quickly adjusted to slip when the tap bottoms in its hole.

Screwdriving Outfit: Hergi Mfg. Co., 75 Third St., Bridgeport, Conn. A power-driven equipment for driving and setting screws or nuts which enables work of this kind to be done with unusual rapidity. After the screw has been run down to the shoulder a ratchet movement can be applied to set the screw to any desired point. This device is automatic in operation, the screwdriving action commencing as soon as pressure is applied and, conversely, power is shut off when the pressure is released.

Thread Milling Machine: General Metals Co., Detroit, Mich. This machine was originally developed by the American Multigraph Co. for the performance of thread milling operations on primer bodies, which this firm was manufacturing for the British and Russian Governments. It proved so successful in this service that a decision was reached to redesign the machine to adapt it for handling general lines of work. This was undertaken by the General Metals Co., which has recently acquired the manufacturing rights.

Gear Generating Machine: Donaldson & Fisher Mfg. Co., Chicago, Ill. A gear-generating machine of exceptionally compact design, which is adapted for cutting spur and helical gears, worms, and worm-wheels, in addition to which it may be employed for generating splined shafts. The capacity is for work up to 14 inches in diameter by 14 inches face width, and cast-iron gears up to 3 diametral pitch may be cut, while the capacity for steel gears is up to 4 diametral pitch. Special provision may be made for handling work of wider face than has been mentioned.

Cross-feed Stops for Lathes: R. K. LeBlond Machine Tool Co., Cincinnati, Ohio. A series of cross-feed stops suitable for application on 15- and 21-inch lathes of this company's manufacture. From four to six hardened steel collars are fitted to a bushing on the cross-feed screw, and separated by spacing washers connected to the bushing. Each stop collar has a projection on its periphery which is engaged by the stop button in line with it. Engagement of one button by its collar pulls it out, leaving the cross-feed screw free to rotate until the next stop collar engages its button, and so on through the series.

Vertical Milling Machine: William K. Stamets, Pittsburg, Pa. A No. 44 heavy-duty vertical milling machine, the design of which differs considerably from established practice in the construction of machines of this type. It has the distinction of having a one-piece frame without an adjustable knee. The table is permanently located 32 inches from the floor, and the head bearing on the column is liberally proportioned. A counterweight inside the column balances the head, so that vertical adjustments may be easily made. Power quick return at 11 feet per minute is available for the cross, vertical and horizontal feed.

ADOPTED STANDARDS OF DESIGN FOR COMPOSITION GEARING

At the October meeting in Boston the American Gear Manufacturers' Association adopted standards of design for composition gearing. This gearing may be subdivided into four classes of gears or pinions, namely, rawhide, fabroil, bakelite, and fiber. The accompanying charts for rawhide pinions have been plotted for regular shop practice, and are self-explanatory, giving all the necessary detail. In regard to bakelite or fiber, the same assembling as used for rawhide applies when the gears are made up of several thicknesses or layers of either of these materials.

A few examples will show the application of the charts. Take for instance, a pinion of 3 diametral pitch. Referring to the left-hand section of the chart in Fig. 2, we find that the minimum allowance between the bottom of the teeth and the bore or dimension *S*, Fig. 1, is 1 inch. This dimension allows for standard rivets and standard keyseats with a maximum bore of approximately 3½ inches. The right-hand section of the chart Fig. 2, shows the amount of extra face width which must be given to rawhide pinions when made according to style No. 1, illustrated in Fig. 1. For instance, it will be seen that for 3-pitch gears the face of the rawhide pinion should be ¼ inch greater than the mating metal gear. The chart Fig. 3 gives the thickness of brass retainers or flanges. In a note at the top of the chart reference is made to style No. 1 and style No. 2 gears which are shown in Fig. 1. As an example illustrating the use of this chart, take, for instance, a pinion having 18 teeth of 3 diametral pitch. For style No. 1 the thickness of retainers will be found to be 9/32 inch and for style No. 2, 11/32 inch. The left-hand section of the chart shown in Fig. 4, gives the diameter of rivets required. For 18 teeth, 3 diametral pitch, the diameter of rivet is ¼ inch. The right-hand section of the chart gives the number of rivets required. For instance, it will be seen that a pinion having 18 teeth of 3 diametral pitch requires five rivets.

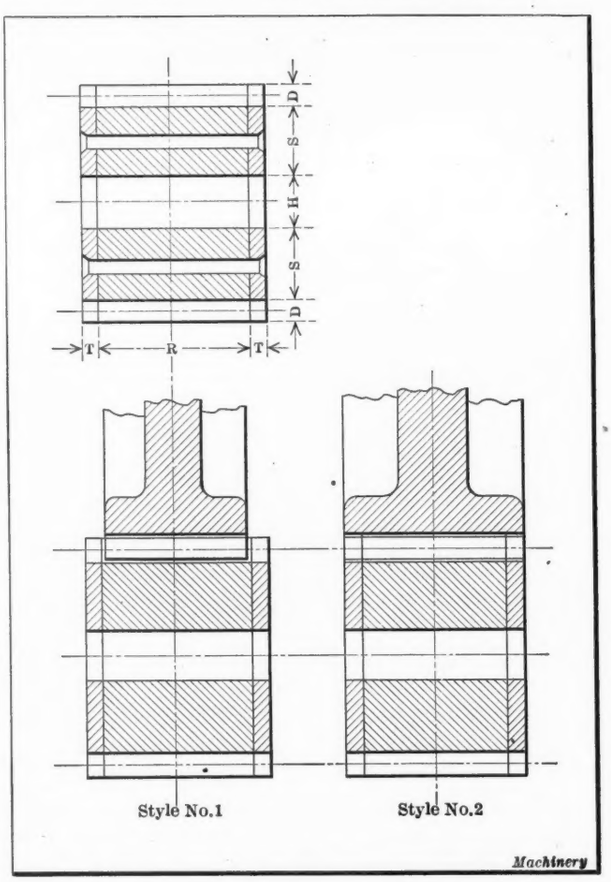


Fig. 1. Two Styles of Composition Gears

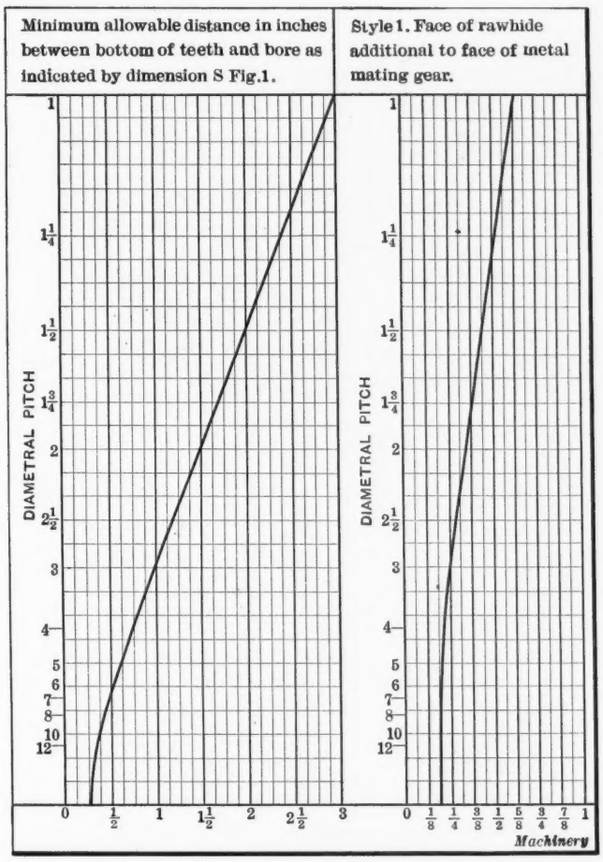

Minimum allowable distance in inches between bottom of teeth and bore as indicated by dimension S Fig.1.
Style 1. Face of rawhide additional to face of metal mating gear.
DIAMETRAL PITCH
DIAMETRAL PITCH
Machinery

Fig. 2. Chart for proportioning Composition Gears according to Adopted Standards

For circular pitch gears, first determine the equivalent diametral pitch and then use the charts in the manner described. Pinions made with hubs, bushings built upon spiders, or with steel or cast-iron flanges are considered to be of special construction, and the charts given do not apply to their design. For strength and economical service, pinions should be made with not less than 15 teeth. To avoid charred condition of the rawhide caused by heat generated through friction when operated at excessive speeds, a maximum pitch line velocity of not over 2500 feet per minute is recommended.

Although in the case of bakelite or fabroil, definite methods of gear design have been developed by the manufacturers and recommendations may be procured from them, the recommendations here made apply equally well to these materials.

* * *

The International Railway Congress Association, the foundations for which were laid at the congress convoked at Brussels in 1885 by the Belgian government for the purpose of celebrating the fiftieth anniversary of its railways, has just been reconstituted under the title of International Railway Association. The association published, up to 1914, a monthly bulletin containing, besides original articles upon all questions relating particularly to the technique, working and organization of railways, reproductions of the most interesting articles appearing in the railway reviews of the world, and detailed reviews of works dealing with railway affairs. At the closing of the eighth session, held in Berne in 1910, it was decided that the ninth session should take place in Berlin in 1915, and the preparations for this session were far advanced in 1914 when Germany declared war and began the invasion of Belgium. Naturally the invasion of the country resulted in the paralysis of activity on the part of the association for nearly five years.

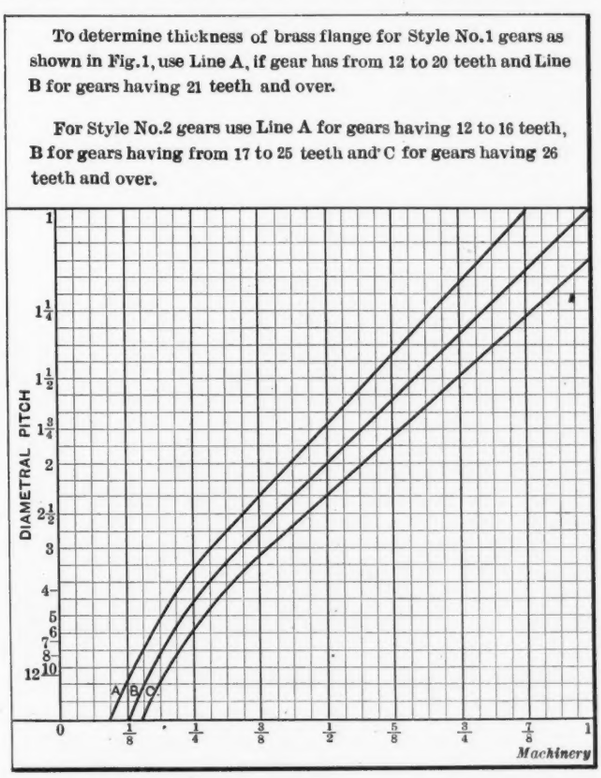

To determine thickness of brass flange for Style No.1 gears as shown in Fig.1, use Line A, if gear has from 12 to 20 teeth and Line B for gears having 21 teeth and over.
For Style No.2 gears use Line A for gears having 12 to 16 teeth, B for gears having from 17 to 25 teeth and C for gears having 26 teeth and over.
DIAMETRAL PITCH
Machinery

Fig. 3. Chart for determining Thickness of Brass Flanges for Composition Gears

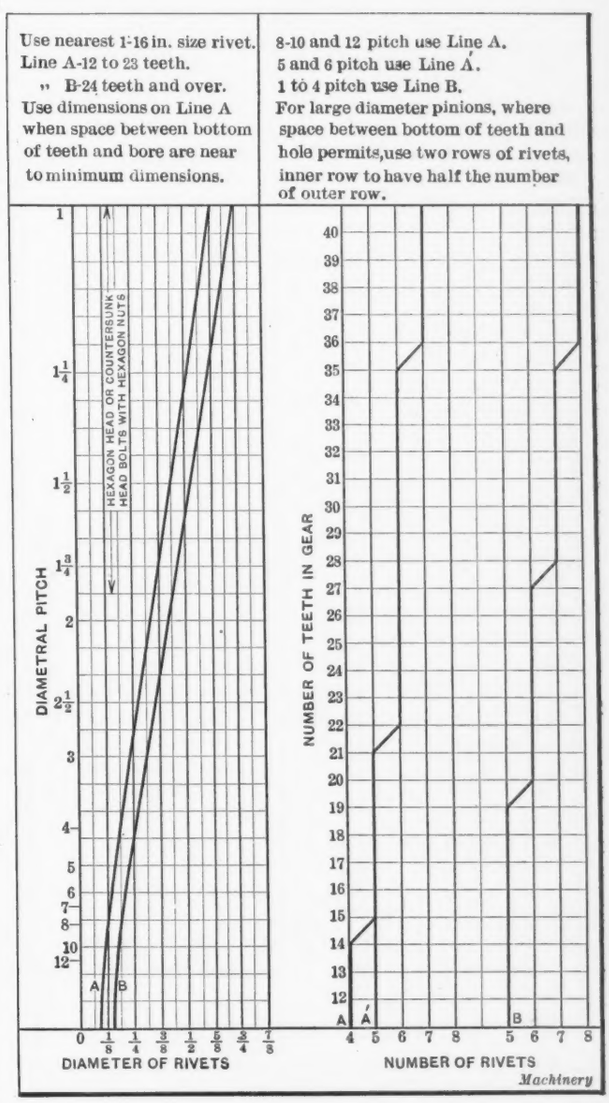

Use nearest 1-16 in. size rivet.
Line A-12 to 23 teeth.
" B-24 teeth and over.
Use dimensions on Line A when space between bottom of teeth and bore are near to minimum dimensions.
8-10 and 12 pitch use Line A.
5 and 6 pitch use Line A'.
1 to 4 pitch use Line B.
For large diameter pinions, where space between bottom of teeth and hole permits, use two rows of rivets, inner row to have half the number of outer row.
HEXAGON HEAD OR COUNTERSUNK HEAD BOLTS WITH HEXAGON NUTS
DIAMETRAL PITCH
NUMBER OF TEETH IN GEAR
DIAMETER OF RIVETS
NUMBER OF RIVETS
Machinery

Fig. 4. Chart for determining Number and Size of Rivets required in assembling Composition Gear Blanks

Industrial Relations Report

A COMMITTEE appointed by the Merchants' Association of New York, upon which served, among others, John F. Galvin, president of the Metal Stamping Co., Long Island City, N. Y.; H. C. Seaman, secretary and treasurer of the E. W. Bliss Co., Brooklyn, N. Y., and Owen D. Young, vice-president of the General Electric Co., Schenectady, N. Y., has rendered a report on industrial relations which contains many valuable points, and which indicates the present trend of thought among employers.

The committee states at the outset that it is not attempting to offer a complete solution of the problem of industrial relations, but it is hoped that the report may be of value in stimulating employers to constant study and effort toward promoting in their individual plants measures based upon justice and conducive to prosperity; and in assisting in arriving at helpful decisions in bringing about harmonious relations with employes.

The change in fundamental industrial relations will be an evolution. With the proper thought and effort on the part of both employers and employes, improvement and advancement will be gradually made and progress will be successful in proportion to the interest and breadth of vision with which the problem is considered. Each advance will show a goal more desirable than that hitherto striven for. Care should be taken that each step is a real advance, not one which will have to be retracted. Employers must take the lead in the effort to apply sound principles to the improvement and advancement of industrial relations; much in the way of leadership is properly expected of them.

Retarding Influences

This evolution, says the report, is being retarded in part by three features of our industrial system which are not compatible with satisfactory industrial relations:

1. The short-sighted determination too often found on the part of employers and employes selfishly to get maximum results without consideration by either of the interests of the other, or of the public, as the controlling motive in industry. This selfish determination of employers and employes has hitherto been recognized by society as entirely proper, yet it is fallacious because it is destructive of maximum production.

2. Lack of understanding and mutual confidence of employers and employes. Suspicion and lack of complete understanding of each element in industry of the just aims, aspirations and problems of all other elements make constructive cooperation impossible.

3. The law of supply and demand as the determining factor in fixing wages and conditions of employment. Many of the results of this economic law are unfair and prejudicial to the interests of both employers and employes, and are socially undesirable.

The Rights of the Public and the Common Interests of Employer and Employe

In view of the detrimental influence of these three features of our industrial system, the committee recommends the recognition by both employers and employes that the determination to achieve national prosperity rather than to enforce maximum selfish returns should be the controlling motive in industry. The community, as such, has a right to insist that industry be carried on in the interest of all citizens rather than for the sole benefit of those engaged directly in it. The permanent welfare of all citizens depends on national prosperity, which is impossible unless there is maximum production at minimum "per unit" cost without impairment either of proper living standards of employes or the ability of the employers to earn a reasonable return on their investment. These requisites of national prosperity cannot be obtained unless employers and employes work together harmoniously with that end in view. Fundamental industrial problems of human relations can be solved upon the accepted basis that without national prosperity the permanent interests of parties to industry cannot be conserved; and that with such prosperity, relations between employers and employes can be worked out with justice to both.

In its broadest aspect, employers and employes unquestionably have a common interest, as it is only through the promotion of the interests of both that the country and the industrial communities in it can enjoy permanent prosperity. The actions and demands of employers and employes become unwarranted when they handicap the industries of the nation that are in competition with foreign industries.

Mutual Understanding Promoted by Conferences

The establishment of a recognized and permanent method of conference between the employer and his employes is recommended: Conferences, at which all subjects of mutual interest may be presented, are essential to the development of understanding and mutual confidence. The mere willingness of an employer to meet employes who have grievances is not sufficient. There should be a definite arrangement—satisfactory to both employers and employes—whereby employes can collectively take up disputes or matters of common interest with employers.

The committee offered no recommendations concerning the plan of conferences which should be established, except that such plans should be worked out jointly by employer and employes, and not prescribed by the employer. Conditions vary so much in different industries and plants that no one plan of conference can be adopted by all. The plan must be adapted to suit the conditions in each plant.

The functions of the conference and the determination of the proper subjects for consideration must be in each case a matter of gradual development. The committee suggests, however, that the following matters should be immediately recognized as included in those which should be discussed in conference: (a) Wages and working conditions, including steps to promote continuous and permanent employment, especially in the case of introduction of new machinery and new processes. (b) Plant conditions affecting health and general welfare of the workers.

General Labor Policies

The limitation of the economic law of supply and demand as a basis of labor policy by the utilization of a more human doctrine is also recommended by the committee. Like the solution of the entire problem of industrial relations, the development of any definite human doctrine which will modify and limit the economic law of supply and demand, will be a matter of evolution. Nevertheless, the committee recommends the immediate recognition of the following principles which will themselves modify the application of the law of supply and demand to a large degree, and are essential to the development of the human doctrine.

1. All wage earners, skilled and unskilled, in return for a fair day's work, have a right to a living wage sufficient to insure the workers and their families the opportunity to live in health and comfort in accord with the concepts and standards of American life.

2. Continuity of employment at normal wages should be maintained up to a point where permanent prosperity and stability of the business—rather than immediate profits—would be endangered thereby.

Profit-sharing not a Solution of Problems Involved

Recently much interest has been shown in plans of sharing in profits and participation in management. Many of these plans are undoubtedly valuable if properly developed and given their proper place. They deserve the careful attention of employers. However, the committee points out that they are merely aids, not remedies. Any plan, the introduction, continuation and final interpretation of which rests solely upon the volition of the employer, will not entirely eliminate dissatisfaction, because it lacks the elements of certainty and permanence, and there is no power of enforcement on the part of employe. Any plan of profit-sharing or participation in management to be of permanent value must receive the unqualified approval of both employer and employes.

The committee concludes by making a special appeal to employers generally to realize that the employment function in management is not second in importance to any other phase of business activity, and that intelligent study must be given to the problems of industrial relations and to the development of a proper labor policy. It is advised that the relations between employes and the management should be placed under the direct supervision of a separate department, and headed by a trained member of the firm.

* * *

ENGINEERS IN 1920 UNITED STATES CENSUS

As a result of the Engineering Council's request to the Director of the Census, the National Service Committee has been successful in effecting a reclassification of engineers so that all technical engineers will be listed as such, separately and distinctly from the non-technical engineers. Thus, the next census will bring an enumeration of all technical engineers together as one unit under the main headings of civil, mechanical, electrical, and mining. Architects will also be enumerated separately. This will enable the engineering profession, the Government, or any other interested organization or person to know exactly how many technical men there are in the United States and in each state. Under separate headings the enumeration will also include non-technical engineers (stationary engineers, locomotive drivers and other engine-men). There are, of course, many practitioners of engineering who do not ordinarily classify themselves under any one of the four headings given above, and there are others whose practice extends into more than one field. More numerous headings or more complex classification is impracticable in the work of the Census Bureau. With the general cooperation of all engineers along these lines a much better enumeration should result than in any preceding census.

* * *

THE NATIONAL EFFICIENCY SOCIETY

The National Efficiency Society at a meeting of its board of governors held on Tuesday, December 23, appointed H. F. J. Porter its executive secretary in place of Charles Dexter Allen, who had resigned on account of other duties which prevented his serving any longer in that position. Mr. Porter was the founder and the executive secretary of the Efficiency Society in 1912, and resigned in 1914 to return to his industrial engineering practice. In 1918, the National Institute of Efficiency and the Efficiency Society united under the name of the National Efficiency Society with headquarters at 119 W. 40th St., New York City. The society believes that the recent movement toward closer cooperation between the employer and the employe in industry through shop committees on which the employe is represented in the management, is the logical step toward higher productive efficiency in industry. Mr. Porter first introduced the shop committee in this country in 1913 and has been identified with the movement ever since. The National Efficiency Society will endeavor hereafter to be a clearing-house and a center of information on this important development in the industrial field.

PROFIT-SHARING INVESTIGATION

The National Civic Federation, under the direction of George W. Perkins, chairman of the Department of Profit Sharing, is making an investigation of profit-sharing methods, following the same lines as the investigation in 1916, the report on which contained an analysis of more than two hundred plans then in operation. There has been considerable demand for this report among manufacturers, and as it is now out of print, it is proposed to publish a new edition containing additional information. Circulars have therefore been addressed to manufacturers asking for the following information: Whether or not any form of profit-sharing is used, and, if so, the date of the installation of the plan, and if discontinued, the reason; average number of employes at the present time; average number of those participating in the plan; results obtained from the plan in regard to the creation of loyalty and the elimination of labor troubles; and any other information bearing upon the subject that would be of value in presenting a comprehensive review of the subject. Manufacturers who have not received the questionnaire may communicate with George W. Perkins, National Civic Federation, 1 Madison Ave., New York City.

* * *

GERMAN MACHINE TOOL SITUATION

Basing his observations upon recent developments in the machine tool situation in Germany, Wilbur J. Page, trade commissioner of the Department of Commerce, summarizes his general impressions of the machine tool situation in Germany as follows: Machine tools can in most cases, be delivered from stock, large machine tool building concerns having from twenty-five to forty machines of each type in stock, at prices that are approximately from 200 to 400 per cent above those previous to the war, as expressed in German marks. Of course, when sold abroad these prices are apparently very much lower, because of the low value of the German mark in foreign currency. In order to buy German machine tools, cash must be deposited in a German bank on receipt of advice that the machines are ready for shipment. A considerable amount of business has been transacted during the last six months with Holland, Sweden, Norway, Denmark, Spain, and South America. A large proportion of the machines made during the last six months have been for the export trade. The chief limiting factor in the output of the machine tool building plants is coal. There is a tendency to bring out new designs of a more specialized nature than those made in the past.

PERSONALS

JOHN CETRULE has been made assistant chief engineer of J. H. Wilhelm, Inc., consulting engineers, 225 Fifth Ave., New York City.

I. C. SCOVILL, previously sales manager of the Collis Co., Clinton, Iowa, has become sales manager of the Detroit Reamer & Tool Co., Detroit, Mich.

HUGO FRANKL is now in charge of the tool and die departments of the Steckert Electric Machine Co., Detroit, Mich., manufacturer of "Eureka" vacuum cleaners.

DAVID J. RICE, for the last three years manager of the Detroit office of the Illinois Tool Works, has become sales manager of the Michigan Tool Co., Detroit, Mich.

GUSTAVE BOTTIN, formerly salesman with the Allied Machinery Co. in Paris, is now connected in the same capacity with J. Horstmann, at 81 Rue Saint-Maur, Paris, France.

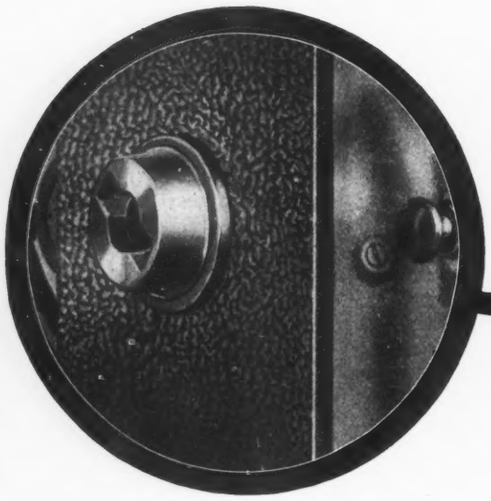
FREDERIC A. PARKHURST, organizing engineer, has opened an office at Room 2611, Grand Central Terminal Bldg., New York City, to consider organization, management, and production problems.

FRANKLIN SCHNEIDER was elected vice-president of the Van Dorn & Dutton Co., Cleveland, Ohio, at the last meeting of the Board of Directors. Mr. Schneider is also president of the Van Dorn Electric Tool Co.

F. G. ECHOLS, vice-president and general manager of the Greenfield Tap & Die Corporation, Greenfield, Mass., has been

The Taper Nose

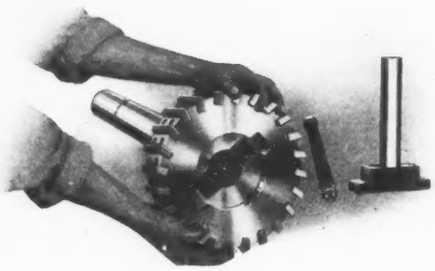
Another Reason for Brown & Sharpe Milling Machines



THE simplicity and fewness of parts is particularly noteworthy. No plates, screws or loose parts are used and when arbor, collet or cutter is in place it is essentially as firm as though a part of the spindle itself.

Only a Drawing-in bolt and Cutter Driver Required to Hold and Drive Face Milling Cutters

The ease with which face milling cutters are attached to spindle is illustrated. Not only does this method make for greater convenience but it insures a positive drive.



Showing Relation of Slot in Cutter to Recess in Spindle

Nose of Spindle Free From Projecting Parts

There are no threads to get bruised—no sharp corners to get broken—no such troublesome, time wasting conditions as "freezing" of cutter to spindle.

It is indeed an important reason for Brown & Sharpe Milling Machines but there are many more described in our Milling Machine book which we know will interest you.

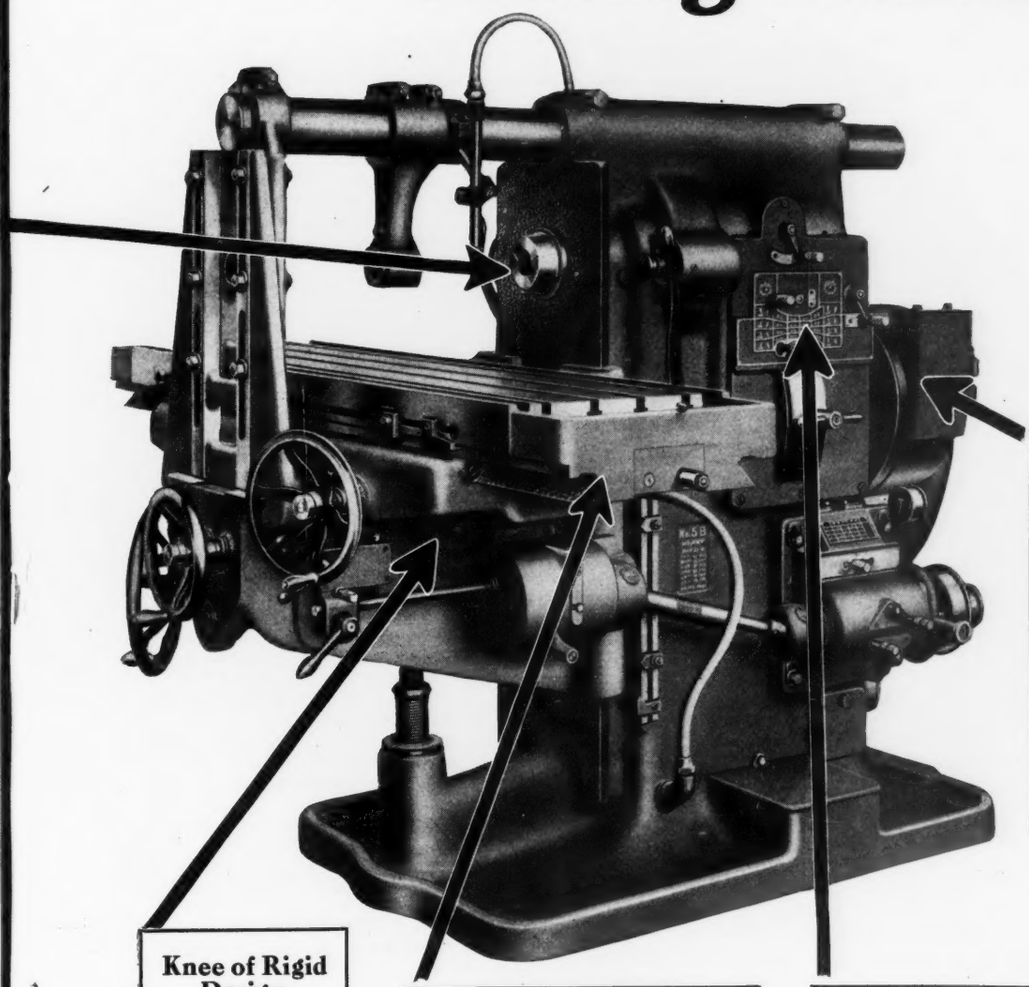
Showing How Cutter Driver is Inserted

May we send a copy?

BROWN & SHARPE MFG. CO.

PROVIDENCE R. I., U. S. A.

Brown & Sharpe Milling Machines



Large Proportioned Driving Pulley

The driving pulley is of large diameter and wide face. It is mounted on a shaft that is supported on both ends by ball bearings which take the pull of the belt.

In heavy service the value of this construction is well appreciated.

Knee of Rigid Design

The vertical depth, heavy sections, and interior transverse ribs, together with long and wide bearing surfaces for both column and saddle, overcome the tendency of the knee to vibrate or sag under the load of saddle and table during operation.

Reinforced Table Support

The wide bearings extend from the outside nearly to the center, because the severe stresses during operation are more successfully resisted when the table is well supported practically its full width. Strong, reinforcing ribs resist buckling tendencies.

Direct Reading Index Plate

All the available spindle speeds are given on a direct reading index plate fastened to the top of the speed case, and the exact position of the levers is clearly indicated. There are no combinations to figure out, as the proper positions for levers are pictorially shown and the operator grasps the idea at once.

elected a director of the corporation to fill the vacancy caused by the resignation of F. O. Wells.

ROBERT KIMBER, who formerly represented the Firth-Sterling Steel Co. in the Hudson River, Brooklyn, and Long Island territory, has been appointed eastern sales representative of the Le Moyne Steel Co., with offices at 30 Church St., New York City.

FREDERICK A. HARDIN has been appointed southern representative for the Victor Saw Works, Springfield, Mass., succeeding E. C. Paddock, who has been transferred to the Middle West. Mr. Hardin was previously connected with Oliver H. Van Horn, of New Orleans.

JOHN A. FOSTER, for the last two years superintendent of the High Speed Hammer Co.'s plant at Rochester, N. Y., and previous to that a department head with the General Railway Signal Co., is now associated with the Taylor-Shantz Co., Rochester, N. Y., in the capacity of factory manager.

F. W. SINRAM, president of the American Gear Manufacturers' Association, was elected president of the Van Dorn & Dutton Co., Cleveland, Ohio, at the last meeting of the Board of Directors of that company. Mr. Sinram has been general manager of the company for several years. He is also treasurer of the Van Dorn Electric Tool Co.

MYRON T. H. BLANCHARD, lately with the Hydraulic Pressed Steel Co., has recently been made a member of the Cleveland sales force of the Tacony Steel Co., Philadelphia, Pa. Mr. Blanchard has had considerable metallurgical experience, having been connected with the metallurgical departments of the Bethlehem Steel Co. and the Canton Spring & Axle Co. of Cleveland.

J. C. WARD, director of Edgar Allen Co., Ltd., Imperial Steel Works, Sheffield, England, is visiting this country in order to keep in close touch with trade conditions and further the cooperation between the Edgar Allen works in Sheffield and the agencies in the United States. Mr. Ward is making his headquarters at the Chicago office of the Edgar Allen Co. where G. R. Bennett is the general manager.

H. G. BAIN, until recently attached to the San Francisco sales office of the Midvale Steel and Ordnance Co., is now a member of the Tacony Steel Co.'s sales organization and will represent that company in the upper part of New York State. Mr. Bain, in addition to a long sales experience, has had considerable practical experience in the mills. He is thoroughly conversant with the tool steel, alloy steel, and forging branches of the steel business.

H. C. BARNES, for the last four years metallurgist and heat-treating engineer for the American Rolling Mills Co., at Middletown, Ohio, and for four years previous to that with the R. D. Nuttall Co., of Pittsburg, Pa. in the same capacity, has become associated with the Allegheny Gear Works, Chateau and Page Sts., Pittsburg, Pa., and will have charge of the metallurgical laboratory and heat-treating departments of the company's new plant.

FREDERICK H. KORFF has recently assumed his new duties as factory manager of C. E. Johansson, Inc., Poughkeepsie, N. Y. Mr. Korff has held the positions of factory manager with H. C. Hinchcliff, Inc.; production manager and mechanical engineer with the Frank S. Betz Co.; assistant general superintendent and production manager with the Stromberg Carburetor Co.; and assistant factory manager with the several plants of the Wright-Martin Aircraft Corporation, manufacturer of the Hispano-Suiza airplane motor.

KINGMAN BREWSTER, formerly vice-president and general sales manager of the Greenfield Tap & Die Corporation, Greenfield, Mass., is now president of the Millers Falls Co., Millers Falls, Mass. Mr. Brewster became associated with the Greenfield Tap & Die Corporation in 1918. Previous to that he practiced law in Springfield, Mass., having had charge of the legal work for a number of New England corporations. His work as counsel for these interests led to his being made vice-president of the Greenfield organization.

CLAYTON O. SMITH, until recently sales manager of the Norton Grinding Co., Worcester, Mass., is now general manager, secretary, and treasurer of the O. S. Walker Co., Worcester, which company has recently been sold by Oakley S. Walker to a group of men prominently connected with the machine tool and supply business. Mr. Smith is a graduate of the Worcester Polytechnic Institute and received his earlier practical engineering training with the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., the C. W. Hunt Co., Staten Island, N. Y., and the Norcross Bros. Co., Worcester, Mass.

RICHARD MARTENS, organizer and director-in-chief of R. Martens & Co., Ltd., London, England, and 6 Hanover St., New York City, has resigned his directorship of the firm and will hereafter devote his entire efforts to the development of direct trade between the United States and Russia. In cooperation with American manufacturers and bankers, plans are being considered for putting into Siberia and the southern part of Russia the necessary tools and machinery to restore agricultural industry as quickly as possible. Mr. Marten's address will remain at present in care of the firm at 6 Hanover St., New York City.

ARTHUR B. MEAD has been appointed district sales manager of Peter A. Frasse & Co., Inc., 417 Canal St., New York City, for the territory covering Philadelphia, middle Pennsylvania, southern New Jersey, Virginia, Delaware, and Maryland. Mr. Mead has been a member of the sales organization at the general offices of the company for several years. His headquarters will be at the Philadelphia office and warerooms, 625 Arch St., where larger stocks of the Frasse electric, tool, and alloy steels, open-hearth steels, Frasse polished drill rods, and Shelby seamless steel tubes, will be carried to meet the growing demand.

E. I. CHAPIN, for the last few years assistant factory manager for the Brown-Lipe-Chapin Co.'s plant in Syracuse, N. Y., has resigned his position to take active charge of the Chapin & Baker Mfg. Co., Syracuse, of which he is now manager. Previous to his connection with the Brown-Lipe-Chapin Co., Mr. Chapin was with the H. H. Franklin Mfg. Co., of Syracuse. The Chapin & Baker Mfg. Co., which was organized by Mr. Chapin and his associates some months ago, is manufacturing a line of special tools, including reamers, counterbores, tool-holders, etc., and is engaged in jig, fixture, and general contract work. Several new lines of tools are being developed, and the plant on Edison St. is being enlarged to meet the needs of this expansion.

FRANK O. WELLS, president of the Greenfield Tap & Die Corporation, Greenfield, Mass., has announced that he has sold out his holdings in this corporation to interests represented by Frederick H. Payne, vice-president of the concern. Mr. Wells will retire as president and from the board of directors, but will remain with the corporation in an advisory capacity. Mr. Wells has spent 45 years of his life in the industry, being the founder of Wells Bros. Co., which is now one of the larger units of the Greenfield Tap & Die Corporation. He began his career as a workman in the Wiley & Russell factory, but in 1874, he started, with his brother, Frederick E. Wells, manufacturing in his own interest. The new business grew so rapidly that it required a new factory, and one was built on Sanderson St., which was afterward greatly enlarged. Later came the merging of the Wiley & Russell company with the Wells Bros. Co. under the name of the Greenfield Tap & Die Corporation, and to this was added the F. E. Wells & Son Co., the Bickford Machine Co., and the Smart Manufacturing Co. During the war Mr. Wells was called into the counsels of the government and gave invaluable assistance in the direction of organizing industries for war production. He was made a member of the National Screw Thread Commission, and this summer went to Europe to consult with leading manufacturers on the question of the world standard screw thread.

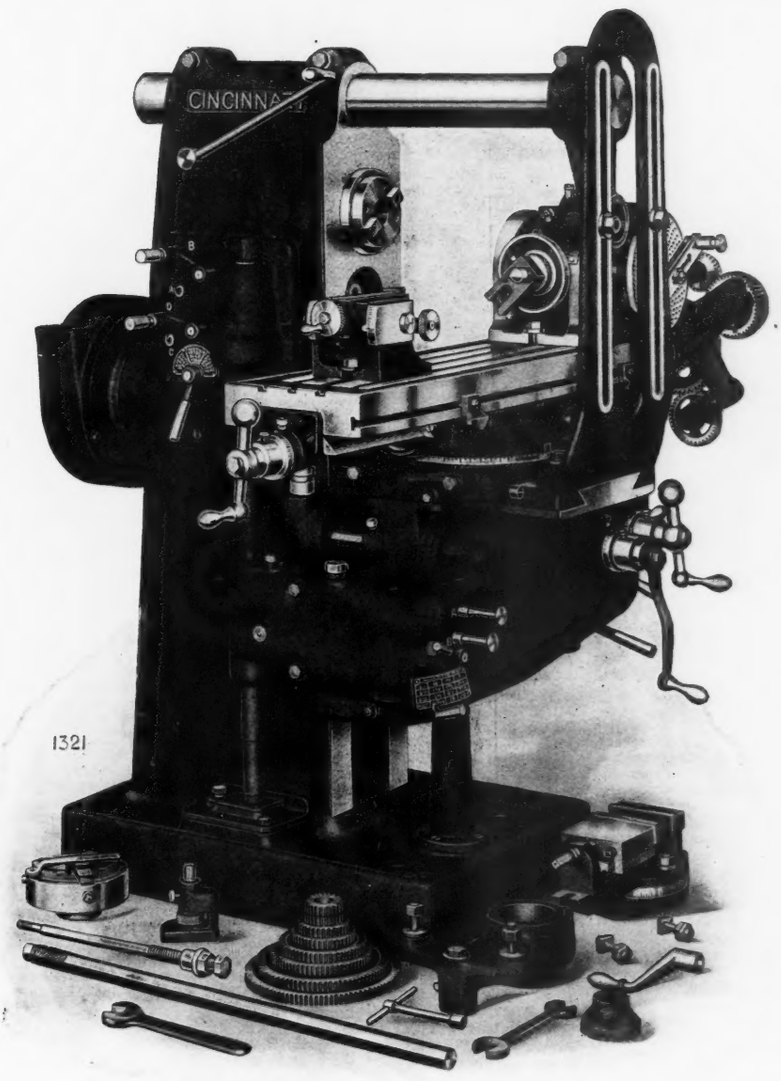
OBITUARIES

H. L. GANTT, one of the best known of the consulting engineers who have devoted themselves to the installation of methods for increasing industrial efficiency, died November 23. Mr. Gantt was born in 1861 and was educated at Johns Hopkins University and at the Stevens Institute of Technology. He was the author of several books on industrial efficiency, and had unusually clear and definite views on the relations between capital and labor and the best means for securing friendly relations between employer and employe. He had been a member of the American Society of Mechanical Engineers since 1888, having served the society as manager from 1908 to 1911 and as vice-president from 1913 to 1915.

CHARLES BURGESS, founder of the Cyclops Steel Works, died at his home in Titusville, Pa. on November 18. Mr. Burgess was born in Pelsall, England, in 1841, and in his early youth became interested in the manufacture of iron and steel products. In 1866, he came to this country and was first employed at Troy, N. Y. He later organized the Burgess, Aston Co., which operated a puddling plant near Pittsburg until 1870. Soon after disposing of his interests at Pittsburg, Mr. Burgess went to Portsmouth, Ohio, where, in 1871, he organized the Burgess Steel & Iron Works in which he retained a controlling interest until 1884, when he went to Titusville where he purchased the plant and business of the Eames Petroleum Iron Works, operating the plant under the name Cyclops Steel Works. In the early stages of the high-speed steel market, Mr. Burgess developed a secret process for the manufacture of high-speed steel. He was considered one of the leaders in tool steel manufacture and was one of the first men to puddle steel for agricultural implements in the puddling furnace.

Announcing a new line of

Small Constant Speed Drive Millers



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1 M and 2 M
Plain, Universal and Vertical

Ask us!

THE CINCINNATI MILLING MACHINE COMPANY

CINCINNATI **OHIO, U.S.A.**

COMING EVENTS

January 8-15—First aeronautical exposition in the Coliseum in Chicago, Ill., given by the Manufacturers' Aircraft Association, Inc., 501 Fifth Ave., New York City.

January 29—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137 Sibley Block, 328 Main St., E., Rochester, N. Y. Secretary, O. L. Angevine, Jr., 547 Arnett Blvd., Rochester, N. Y.

February 2-6—First annual mechanical inspection equipment exposition and convention of the American Society of Mechanical Inspectors at the Hotel Astor, New York City, Secretary, Henry F. Winter, 35 W. 39th St., New York City.

May 12-15—Seventh national foreign trade convention in San Francisco, Cal. Secretary of the National Foreign Trade Council, O. K. Davis, 1 Hanover Square, New York City.

SOCIETIES, SCHOOLS AND COLLEGES

Clarkson College of Technology, Potsdam, N. Y. Bulletin containing views of the college.

University of Utah, Salt Lake City, Utah. General catalogue of the university for 1919-1920.

Johns Hopkins University, Baltimore, Md. Catalogue of the Department of Engineering of the university.

University of Minnesota, Minneapolis, Minn. Bulletin of the College of Engineering and Architecture for 1919-1920, containing calendar, courses of study, and general information.

BOOKS AND PAMPHLETS

War-time Changes in Wages. Research Report No. 20. 128 pages, 6 by 9 inches. Published by the National Industrial Conference Board, 15 Beacon St., Boston, Mass.

Works Councils in the United States. Research Report No. 21. 135 pages, 6 by 9 inches. Published by the National Industrial Conference Board, 15 Beacon St., Boston, Mass.

Thirty-sixth Annual Report of the Department of Labor of the State of Michigan. 766 pages, 6 by 9 inches. Published by the Department of Labor of the state of Michigan, Lansing, Mich.

Some Tests of Light Aluminum Casting Alloys—the Effect of Heat-treatment. By P. D. Merica and C. P. Karr. 31 pages, 7 by 10 inches. Published by the Department of Commerce, Washington, D. C., as Technologic Paper No. 139 of the Bureau of Standards. Price, 10 cents.

Mechanical Properties and Resistance to Corrosion of Rolled Light Alloys of Aluminum and Magnesium with Copper, with Nickel, and with Manganese. By P. D. Merica, R. G. Waltenberg, and A. N. Finn. Published by the Department of Commerce, Washington, D. C. as Technologic paper No. 132 of the Bureau of Standards. Price, 5 cents.

Exercises in Lettering—Vertical Gothic. By George G. Greene. 31 pages, 2½ by 5 inches. Published by the Bruce Publishing Co., Milwaukee, Wis. Price, 10 cents.

This little book is one of a vest pocket series of exercises in lettering which has been brought out for the purpose of teaching the student to letter rapidly and neatly. It contains sixteen exercises, showing the correct form and proportions of vertical Gothic letters and numbers.

Millwrighting. By James F. Hobart. 454 pages, 6 by 9 inches. Illustrated. Published by the McGraw Hill Book Co., Inc., New York City. Price, $4.

In the second edition of this book, which has just been brought out, a chapter has been added dealing with the installation and control of electrical motors. The conditions under which the millwright works have changed greatly during the last few years, and an idea of how these changes affect millwright work is given in the new material. Several changes and corrections have been made in the original text to bring the book up to date.

Robison's Manual of Radio Telegraphy and Telephony. By Rear Admiral S. S. Robison, U. S. Navy. 307 pages, 6 by 9 inches. Published by the U. S. Naval Institute, Annapolis, Md. Price, $1.50.

This is the fifth revision of a radio manual for the use of student operators and others, presenting the elementary principles of the art of radio telegraphy and telephony and describing apparatus commonly used. The fourth and fifth editions have been brought up to date by Captain D. W. Todd, U. S. Navy, and Commander S. C. Hooper, U. S. Navy. The latest edition contains much material that was confidential during the war. This book is used as the standard for the Navy and Shipping Board.

Machine Tool Operation—the Lathe. By Henry D. Burghardt. 326 pages, 4¾ by 7½ inches. Illustrated. Published by the McGraw-Hill Book Co., Inc., New York City. Price, $2.

This book treats of the principles and elementary operations of machine shop work, referring particularly to lathe construction and operation. The book is divided into two main parts, the first treating of the lathe, and the second of bench work and work at the forge. An idea of the material covered will be gained from a list of the chapter heads: The Machinist's Trade; Lathe Construction and Manipulation; Cutting Tools and Cutting Speeds; Measuring Tools; Centering; Facing; Turning; Chucking Work; Tapers and Angles; Threads and Thread Cutting; Faceplate Work; Hammers, Screwdrivers, Wrenches, and Hacksaws; Laying Out; Chipping, Filing, and Scraping; and Work at the Forge.

NEW CATALOGUES AND CIRCULARS

Crogan Mfg. Co., Bangor, Me. Circular of steel measuring tapes.

Aluminum Castings Co., Cleveland, Ohio. Circular of Lynux brass and bronze bushings and bearings.

Baldwin Locomotive Works, Philadelphia, Pa. Record No. 94, containing specifications of tank-frame locomotives.

General Electric Co., Schenectady, N. Y. Pamphlet B-3549, descriptive of the "Pyrotip" electric burner for lead burning.

Electric Controller & Mfg. Co., Cleveland, Ohio. Circular of Type ZB alternating-current starting switches for small induction motors.

S. P. Rockwell, 122 Dickerson St., Syracuse, N. Y. Circular descriptive of the Rockwell hardness tester for testing the hardness of metals.

Smith & Serrell, 144 Cedar St., New York City. Bulletin 103, describing the construction and use of "Pintite" rigid couplings for lineshafting.

Lewis-Shepard Co., 49 Binford St., Boston Mass. Circular illustrating the use of "Jacklifts" for moving loaded platforms in manufacturing plants.

Black & Decker Mfg. Co., Towson Heights, Baltimore, Md. Catalogue illustrating and describing Black & Decker electric air compressors, portable electric drills, and electric valve grinders.

Gisholt Machine Co., 9 S. Baldwin St., Madison, Wis. Circular treating of Gisholt turret lathes, horizontal boring and drilling machines, vertical boring mills, special lathes and universal tool grinders.

Federal Steel Co., Penobscot Bldg., Detroit, Mich. Bulletin 1, descriptive of the Federal center for lathes, milling machines, gear-cutters, and grinders, which is made with an inserted high-speed steel point.

Bucher-Smith Co., East Liverpool, Ohio. Catalogue of Bucher-Smith portable keyseaters, which are made in hand and electrically operated styles. Catalogue of ball-bearing jiggers and roller-bearing pull-downs.

Smalley-General Co., Inc., Bay City, Mich. Bulletin E containing charts giving the necessary data for milling work under any condition of feeds and speeds on the Smalley-General No. 1 thread milling machine.

Wodack Electric Tool Corporation, 23-27 S. Jefferson St., Chicago, Ill. Circular describing and giving specifications for Wodack portable electric drills made in four sizes—¼, ⅜, ½, and ⅝ inch respectively.

McLain-Carter Furnace Co., Goldsmith Bldg., Milwaukee, Wis. Catalogue describing McLain-Carter open-hearth furnaces for melting steel. The illustrations show installations of these furnaces in a number of plants.

Cleveland Punch & Shear Works Co., Cleveland, Ohio. Calendar for November, 1919, to May, 1920, of the working days arranged by weeks, each sheet also illustrating the punches, dies, and other products made by the company.

Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. Catalogue 86B, describing the construction, use, and application of the Leeds & Northrup optical pyrometer, a portable instrument for making temperature measurements.

Werner G. Smith Co., Cleveland, Ohio. Booklet entitled "The Chemistry of a Core," treating of "Linoil"—a core oil for use in core sand. The booklet illustrates clearly by means of magnified photographs the function of oil in sand cores.

Bilton Machine Tool Co., Bridgeport, Conn. Catalogue of milling cutters, small tools, and machine tools, including automatic milling machines, gear milling machines, thread milling machines, plain milling machines, riveting machines, and drilling machines.

C. E. Johansson, Inc., Poughkeepsie, N. Y., is issuing a publication known as "The Johansson Journal," which contains information relative to the product of the company, the intention being to illustrate and describe in each number specific uses of Johansson gages and precision tools.

Westinghouse, Church, Kerr & Co., Inc., 37 Wall St., New York City. Circular illustrating a number of shops that have been constructed by this company. The W. C. K. method of construction comprises the laying out of the equipment and the construction of the building to suit the lay-out.

J. G. White Engineering Corporation, 43 Exchange place, New York City. Catalogue illustrating a nitrate plant designed and constructed by this company. The work of the company comprises engineering investigations and reports, designing and construction work, and the purchase of apparatus, materials, and supplies.

Davis-Bournonville Co., Jersey City, N. J. Circular describing briefly the Davis acetylene flare-light generator—a portable lighting apparatus—and suggesting some of its many possible uses. This equipment can also be used for lead burning, light welding, and other industrial purposes requiring a low acetylene pressure only.

Bacharach Industrial Instrument Co., 422 First Ave., Pittsburg, Pa. Pamphlet F, describing a new pressure-volume indicator for the control of air delivery to cupolas, suitable for either permanent installations or testing purposes. Pamphlet P, treating of pitot tubes and orifices for measuring the flow of gases in connection with hydro flow meters.

Franklin Mfg. Co., 738 Gifford St., Franklin, Pa. Catalogue F C 7-19, treating of Franklin heat insulating and fuel saving products. The bulletin contains engineering data that will enable fuel users to calculate the losses, determine the best material for each condition, and estimate the yearly saving effected through the installation of heat insulating products.

Chicago Flexible Shaft Co., 1154 S. Central Ave., Chicago, Ill. Catalogue 75, of Stewart gas and oil furnaces, which are made in three types, namely, the oven, crucible and forge types. In addition to illustrating and describing the furnaces and giving specifications of the various sizes and types, information is given on the hardening of high-speed tool steel and practical hints on hardening steel.

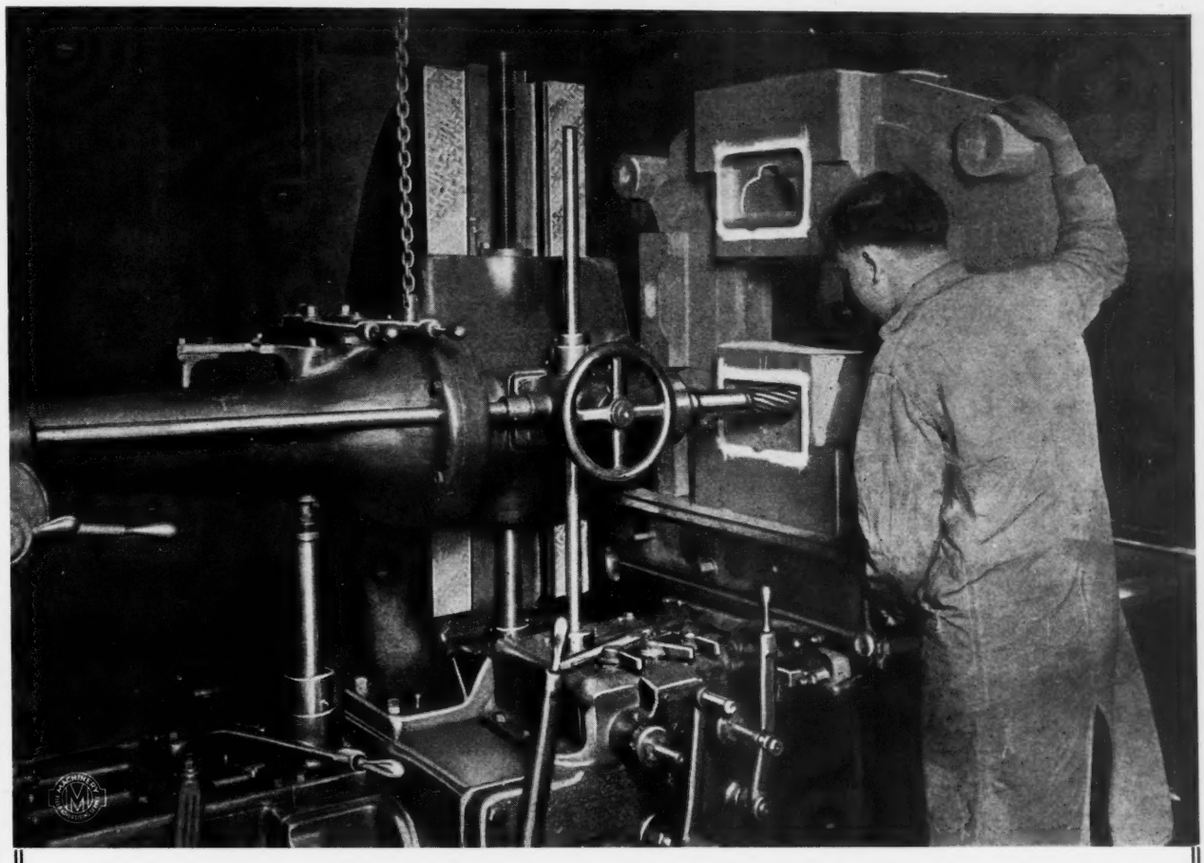
Clark Equipment Co., Buchanan, Mich. Catalogue 17, of "Celfor" high-speed twist drills, reamers, countersinks, flue cutters, lathe tools, and internal gear drive axles. Dimensions, prices, and other data covering these tools are given. The last section of the book, covering general information gives tables of proper feeds and speeds for "Celfor" drills, drill lists with taps for U. S. standard threads, machine screw taps, taps with V-threads, pipe taps, etc.

Sipp Machine Co., Keen and Warren Sts., Paterson, N. J. Bulletins 4 and 5, illustrating and describing the Sipp quick-change-speed sensitive drilling machines, which are made in three types, either single- or multiple-spindle styles with 6½-, 8-, and 12-inch overhang, respectively. Circular descriptive of the automatic power feed for Sipp quick-change-speed sensitive drilling machines. Booklet entitled "Facts" containing excerpts from letters of recommendation written by users of the Sipp drilling machines.

Onondaga Steel Co., Syracuse, N. Y. Catalogue of Onondaga high-speed steel, giving dimensions, weight, prices, etc., of rounds and squares, flats, disks, and blocks. The catalogue contains information on selecting quenching oils; directions for heat-treatment, including a color chart that gives an idea of the various heats required; and suggestions for steel conservation, and the selection of high-speed steel scrap. A number of useful tables are included, among which are tables of sizes and weights of high-speed steel bars in metric and English measurements, the millimeters and kilograms being printed in red, and the inches and pounds in black.

Eastern Machine Screw Corporation, New Haven, Conn., maker of the H & G line of self-opening die-heads and collapsible taps, has just issued a new catalogue of 96 pages, containing considerable threading information and tables pertaining to thread cutting. The book is well illustrated and comprises practically a text-book on the subject. In addition to describing the H & G die-heads, collapsible taps, chasers for H & G die-heads, stock, system, and service, instructions are given for opening the die-heads, installing the chasers, closing the heads, adjusting for pitch diameter, and grinding the chasers. Information is given on cutting speeds, lubricants, and much other material relative to standard thread forms, decimal equivalents, weight per foot of screw stock, etc. A revised price list has also been issued.

Norton Co., Worcester, Mass., has issued the following publications: "Safety Bulletin," describing causes and remedies of troubles common among men doing shop work; "Health Bulletin," containing suggestions for preventing troubles common to shop men, and for encouraging the maintenance of sanitary conditions in the shop and in the home; "Principles of Cylindrical Grinding," treating of work-speed, depth of cut, grade of wheel, wheel-speed, finishing, etc.; "Storage, Handling, and Supervision of Grinding Wheels"; "Safety as Applied to Grinding Wheels," discussing preventive and protective safeguards applied to grinding wheels and machines; "Safety Code for the Use, Care, and Protection of Abrasive Wheels"; "Alundum Tile and Terrazzo Aggregates"; "Tests of Alundum Tile at Columbia University"; "Indian Hill—an Industrial Village," containing a description of homes constructed by the company for its employes.



"Satisfactory" comes the report on every test

One of the finest tool shops in the Middle West uses two Lucas Precision Boring Machines on large drill jigs, punches, dies and gages for manufacturing automobile parts. Tolerances are close, mostly plus or minus .0005", and during the war these machines were run continuously 24 hours a day.

LUCAS

"Precision" Boring Machines

respond 100 per cent to every kind of test. The one here shown is milling openings measuring 11" by 6½" by ¼" deep in a cast iron die shoe for a piercing die used in making front frame connections. The shoe itself measures 37" by 48" by 8" thick.

We'd like to tell you more—to explain in detail the distinctive advantages of this wide range precision tool. Write us.

LUCAS MACHINE TOOL CO. NOW AND ALWAYS OF **CLEVELAND, OHIO, U.S.A.**

FOREIGN AGENTS: Alfred Herbert, Ltd., Coventry. Societe Anonyme, Alfred Herbert, Paris. Societe Anonyme Belge, Alfred Herbert, Brussels. Allied Machinery Co., Turin, Barcelona, Zurich. Benson Bros., Sydney, Melbourne. V. Lowener, Copenhagen, Christiania, Stockholm. R. S. Stokvis & Zonen, Rotterdam. Andrews & George Co., Tokyo.

P. W. V. Automatic Machine Corporation, Fitchburg, Mass. Catalogue detailing the design, construction, and manufacture of "Radical" automatic screw machines. The plan of presentation is rather unusual, and is such as to give a very clear and comprehensive idea of the construction of these machines. The first pages show the assembled machine with symbol numbers to designate the different parts, and the following pages show each part and give specifications and necessary data. The illustrations show the machine in what may be termed the process of manufacture, the first view showing the pan, and the subsequent views showing the addition of each unit, in the correct order of assembly, until the machine is shown complete with all its parts assembled. Attention is called to the fact that the threading mechanism is an entirely separate unit, which can be easily removed if it is desired to use the position that it occupies for other tools.

TRADE NOTES

Hyatt Roller Bearing Co. has established an office at 309 Marshall Bldg., Cleveland, Ohio, to accommodate its customers in that territory.

V. Lowener, 114 Liberty St., New York City, desires to receive catalogues and price lists for all kinds of automobile accessories and supplies for export to Scandinavia.

Erie Crucible Steel Co., Erie, Pa., has recently received a contract from the United States Navy for a large quantity of Erie high-speed steel for the Naval Ordnance plant at Charleston, W. Va.

Van Dorn Electric Tool Co., Cleveland, Ohio, manufacturer of portable electric tools—drills, reamers, and grinders—has completed a new four-story building, giving the plant 30,000 square feet of additional floor space.

Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York City, announces the opening of a new department which will handle exclusively a large assortment of high-grade automobile supplies and accessories.

Willard Machine Tool Co., Cincinnati, Ohio, manufacturer of lathes, has erected a 100- by 65-foot addition to its plant. This addition will considerably increase the capacity of the firm to take care of its growing business.

Wilmarth & Morman Co., 1180 Monroe Ave., N. W. Grand Rapids, Mich., manufacturer of grinding machinery, has established an eastern branch office at 1 Madison Ave., New York City, with W. E. Heibel, eastern district manager, in charge.

Warner & Swasey Co., Cleveland, Ohio, announces that the following changes have been made in the sales department: A. C. Cook has been made general sales manager, L. K. Berry, domestic sales manager, and Charles J. Stilwell, foreign sales manager.

Bridgeport Drafting & Engineering Co., Warner Bldg., Bridgeport, Conn., designer of special automatic machinery, jigs, fixtures, and tools, has installed a catalogue filing system, and would like to receive catalogues from concerns handling tool and shop equipment, structural steel, and sheet-metal work.

Smalley-General Co., Inc., Bay City, Mich., has increased its capitalization from $50,000 to $525,000. The management and officers of the company remain the same. The new capitalization will permit the company to increase its production of thread milling machines, and serve its customers more efficiently.

St. Louis Machine Tool Co. is building an addition to its plant at 932 Loughborough Ave., St. Louis, Mo., which will practically double the capacity, affording 13,000 square feet of additional floor space. This enlargement was made necessary by the increasing demand for the grinding, polishing and tapping machinery made by this company.

Compton & Knowles, Worcester, Mass., builders of textile machinery, are planning to increase their plant by an addition calling for an expenditure of approximately $300,000 for buildings, including an extension of the company's foundry in Providence. A building six stories in height will also be erected on the site of the present forge shop in Worcester.

Crescent Washing Machine Co., 840 Larrabee St., Chicago, Ill., announces that the Nivin metal parts washing machine will hereafter be known as the "Crescent" metal parts washing machine. The change of name is made merely for the purpose of identifying the product with the company, and no change will be made in the machine, factory, personnel, or policy.

Black & Decker Mfg. Co., Towson Heights, Baltimore, Md., has opened an office on the Pacific coast, at 201 Maynard Bldg., Seattle, Wash. The office is in charge of A. E. Nordwall, who will attend to the distribution of the Black & Decker products in the state of Washington, working under the direction of the main Pacific coast office at 918 Hearst Bldg., San Francisco, Cal.

Fairbanks, Morse & Co., Inc., 900 S. Wabash Ave., Chicago, Ill., announce that they will build a foundry in Beloit, Wis, that will cover 11 acres at a cost of $1,500,000. The structure, when completed, will be 900 feet long and 550 feet wide, which is said to equal any foundry in the world in size. It will have an ultimate capacity of from 350 to 400 tons of gray iron daily and will employ 1500 men.

Bound Brook Oil-less Bearing Co., Bound Brook, N. J., has completed another new addition to its plant, 100 by 180 feet. A new power plant has also been added as well as an office building, 100 by 40 feet, two stories high. The new building adjoins the foundry which was completed in 1917. These additions have been made necessary by the increasing demand for Bound Brook and Nigrim oil-less bushings.

Pneumatic Scale Co., Norfolk Downs, Boston, Mass., has recently placed a contract with the Aberthaw Construction Co. of Boston, for the immediate erection of a manufacturing and office building of reinforced concrete. The new building will be three stories high and will cover an area of 150 by 160 feet. Its completion will practically double the capacity of the plant. Work on the new building is already under way.

Doehler Die-casting Co., Brooklyn, N. Y., manufacturer of die-castings in white metal, aluminum, and brass alloys, and bronze-back and aluminum-back babbitt-lined bearings, has recently purchased a seven-acre tract in Chicago, Ill., on which a modern one-story concrete steel and brick structure will be erected for the manufacture of die-castings and bearings. The contract for the building has been let and operations have been started.

Firth-Sterling Steel Co., whose New England headquarters have been at 35 Oliver St., Boston, Mass., for a generation, will move during the month of January, the Oliver St. property having been purchased by the Federal Reserve Bank. After February 1 the Firth-Sterling Steel Co. will occupy its new warehouse at 85-91 W. First St., South Boston, where a complete stock of "Blue Chip," high-speed, and other Firth-Sterling tool and die steels will be carried.

Federal Bearings Co., 42 William St., Poughkeepsie, N. Y., has started construction on an addition to its plant, which has become necessary in order to take care of its largely increased business. When this is completed in the early spring, the factory capacity and production will be more than doubled. An increase in capital stock from $1,000,000 to $2,000,000 has also been announced. A certain part of this new stock will be sold to finance the expansion.

American Machinery Syndicate, Inc., 35-37 W. 39th St., New York City, announces that a company has been formed in Madrid, Spain, with a capital of $100,000 to erect a factory for the manufacture of commercial gears, and that this factory will be equipped completely with American machine tools, the purchase of which has been entrusted to the American Machinery Syndicate, Inc. Henry S. Moos, president of the American Machinery Syndicate, Inc., is one of the directors of the Spanish company.

Mulliner Bros., 445 S. Warren St., Syracuse, N. Y., announces the opening of offices as manufacturing engineers. The engineering department of the company is prepared to develop commercial machine models, mechanical ideas or patents, and to design and supervise the building of special machinery and manufacturing equipment, as well as to assist in placing mechanical products on the market. The mechanical and technical advertising department will develop catalogues, booklets, and bulletins.

Black & Decker Mfg. Co., Towson Heights, Baltimore, Md., announces that it will exhibit the following products at the automobile show to be held in New York, in January: "Lectro-flater" electric air compressors, portable electric drills, electric valve grinders, a 6-foot Black & Decker electric air compressor, and a portable tire inflation outfit. Models of electric air compressors, electric drills, and electric valve grinders will be operated under their own power at slow speeds to demonstrate the actual functioning of each part.

Wilkins, Champion & Wilkins, London, England, which firm is represented in the United States by Charles H. Champion, 347 Fifth Ave., New York City, in a purchasing capacity, desires to be placed in touch with manufacturers of mechanical and electrical labor-saving appliances with a view to their sale in the United Kingdom. The firm is especially interested in automobile accessories, tires and shoes, electrical fixtures and fittings, and domestic electrical apparatus, such as washing machines, vacuum cleaners, motor-driven sewing machines, electrical water heating apparatus, etc.

Greenfield Tap & Die Corporation, Greenfield, Mass., announces that Frank O. Wells, president of the corporation, has sold out his holdings to interests represented by Frederick H. Payne, vice-president of the concern. Mr. Wells will retire as president and from the Board of Directors, but will remain with the corporation in an advisory capacity. Mr. Payne, to whom Mr. Wells has sold, was prominent in the merging of the Wiley & Russell and Wells Bros. companies. During the war he accepted a commission as Major in the Ordnance Department and was stationed in Bridgeport, Conn.

Dittmer Gear & Mfg. Corporation is a new concern which has been organized at Lockport, N. Y., with a capitalization of $175,000, for the manufacture of automobile motor truck and tractor transmissions, gears and shafts. A lot, 264 by 272 feet, has been purchased on which a steel, brick and concrete plant will be constructed, having a floor space of 22,000 square feet. The president of the company is A. H. Dittmer. Mr. Dittmer has had considerable experience in the production of automobile parts, having been associated for a number of years with several of the large automobile industries.

Norma Co. of America, manufacturer of Norma ball and roller bearings, has moved its factory from the Bronx, New York City, to Anable Ave., Long Island City, N. Y., where a modern four-story reinforced concrete building has been acquired. Under the new arrangement a largely increased factory space has been secured, making possible an increased output of Norma bearings to meet the growing demand. The new plant is being equipped with the special machines needed for precision manufacture and the full capacity will be available shortly. The executive offices at 1790 Broadway have been consolidated with the factory at the new address.

Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill., has recently constructed an extension to its Belmont foundry at Indianapolis, Ind., which comprises two new furnace buildings; for the present only one furnace of 15-ton capacity will be installed. The company is also purchasing machinery such as rolling mills, sand-blast and other foundry equipment needed to take care of the additional capacity. The building will be 70 feet wide by 400 feet long. These additions are being made in order to give better service to the customers and to take care of the constantly increasing demand for Link-Belt malleable iron chains, and for elevating, conveying, and power transmission purposes.

A. H. & F. H. Lippincott, 24th and Locust Sts., Philadelphia, Pa., manufacturers of screw machine products, announce that they have purchased the assets of the Carlson-Wenstrom Co. and the Carwen Tool & Steel Co., Erie Ave. and Richmond St., Philadelphia, Pa., and will continue, under the direct supervision of A. H. & F. H. Lippincott, the manufacture of the Carwen dynamic balancing machine in conjunction with their screw machine product business, on a much larger scale. Joseph A. Ganster, will be associated with the corporation as director and works manager, and Jacob Lundgren, as engineer. The business will be conducted under the corporate name of **Lippincott-Carwen Corporation.**

Detroit Hexagon Drill Co. has been reorganized and is now located at its new plant at 27-29 Woodward Ave., Detroit, Mich. The company occupies four floors in the building, and expects to accelerate production immediately. The new officers are W. A. Smith, president and general manager; William S. Manning, vice-president; J. W. Donaldson, treasurer; and E. H. Jenks, secretary. Mr. Smith was formerly general manager of the Russell Motor Axle Co.; Mr. Manning was vice-president of the Manning-Blake Tool & Die Co.; Mr. Jenks was secretary of the Russell Wheel & Foundry Co.; and Mr. Donaldson has been connected with the Detroit Hexagon Drill Co. since it was started. This concern is now making a five-lipped drill.

Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill., reports that it has received orders during the month of October in excess of any previous month since the signing of the armistice. This is also true of its English and German subsidiaries. While the German subsidiary was seized by the German Government and has been run under compulsory administration since the United States' participation in the war, the compulsory administration has now been abolished and the management has been transferred back to the Chicago Pneumatic Tool Co. Reports show that the German company was well managed during the war and is now operating on a satisfactory basis. Arrangements have been made to materially increase production.

Hooven, Owens, Rentschler Co., Hamilton, Ohio, has opened a new office in Philadelphia Pa., at 2120 Land Title Bldg. C. M. Decker, formerly with the R. D. Wood Co., has been made manager. The company has also opened a new office at Richmond, Va., with E. H. Fairchild, formerly of the C. & G. Cooper Co., in charge. The following additions to the force of the Hooven, Owens, Rentschler Co. are announced: E. S. Cooley, who was previously associated with the Fall River Ship Building Co., is now connected with the New York office; Henry E. Balsley, formerly with the American Bridge Co., has been made manager of the Chicago office; and R. C. Holman, who was previously in the centrifugal department of the General Electric Co., is in charge of all blowing engines.

O. S. Walker Co., Worcester, Mass., manufacturer of grinding machines and magnetic chucks, has been sold by Oakley S. Walker to a group of men prominently connected with the machine tool and supply business, and the reorganization of the corporation has been completed, the new management having assumed control. The name of the company will remain unchanged. The sale includes the company's plant on Rockdale St., Greendale. The officers of the company now are: President, W. B. McSkimmon, Boston; vice-president, J. H. Drury, Athol; and general manager, secretary, and treasurer, Clayton O. Smith, who was until recently sales manager of the Norton Grinding Co. Isaac F. Williams, who was manager of the business before its reorganization, will remain with the company. William F. McCarthy, of Boston, is also a director.